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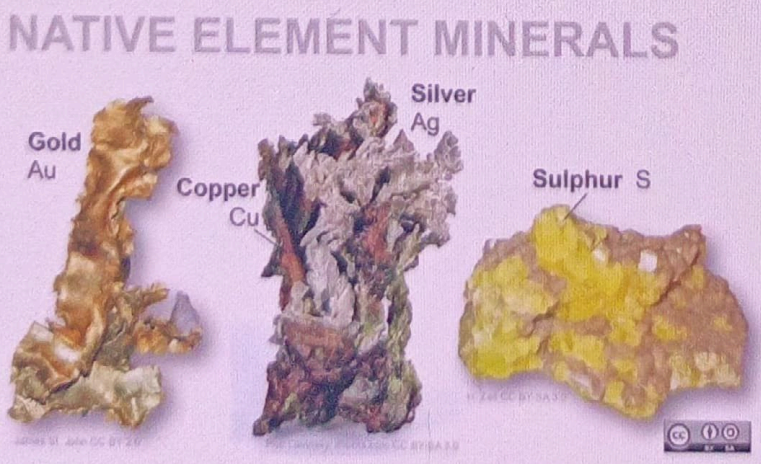
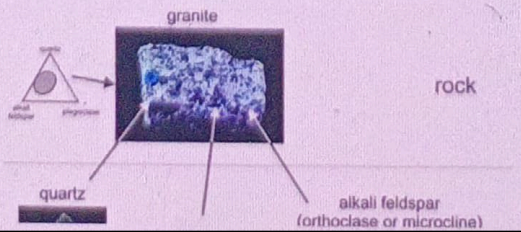
Mining Geology

- **Mining** – It is the process of excavating minerals of economics value from the earths crust for benefit of mankind.
- **Geology** – It means science of the earth and deals with the nature and origin of the rocks that constitute the earth.
- **Mineral** – It is a homogenous and naturally occurring substance having definite physical properties and a composition that may be expressed by a chemical formula.

Occurrence of minerals

- More often minerals occur in crystalline form
- Few minerals occur as single elements e.g. native gold, silver, graphite
- Most minerals are composed of two or more elements in chemical composition e.g. quartz (SiO_2), hematite (Fe_2O_3)
- Most rock forming minerals are oxides, chlorides, sulphides, carbonates, sulphates or silicates.
- A rock may be composed of one minerals only
- Granite is a rock composed essentially of three separate minerals; quartz, felspar and mica





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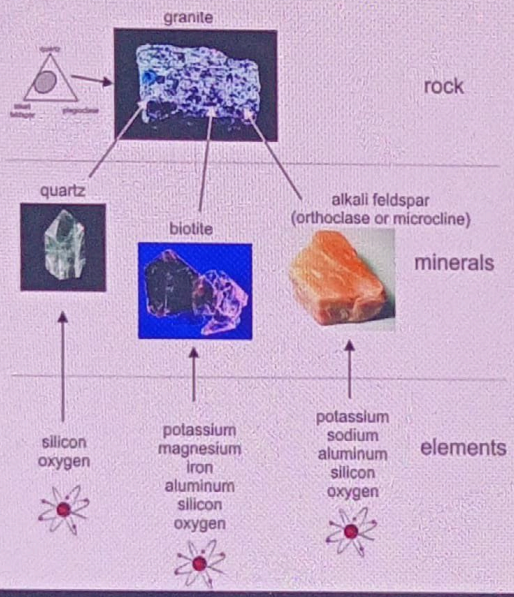
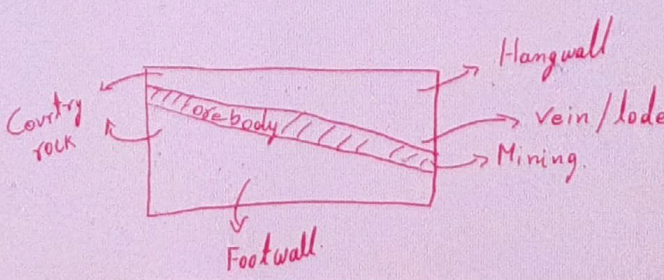
NATIVE ELEMENT MINERALS



Definitions

- **Bed rock** – It is any rock lying in the position in which it was formed; it is therefore not broken up
- **Country rock** – It is that rock which is predominant in the area and which contains the orebody. The country rock forms the footwall and the hangwall.
- **Seam** – It is a deposit limited by two, more or less parallel planes, a shape which is typical of sedimentary rocks. The term is generally used for coal, e.g. a coal seam.
- **Gangue** – The uneconomic rock or mineral associated with it which has to be excavated and discarded is called rejection, dirt or waste in coal mining practice and gangue in metal mining practice
- **Ore** – It is a rock which contains mineral and which can be used for economical extraction of metal after processing to separate mineral from gangue. Ores usually occur in veins or lodes.
- **Straight ore** – If an ore, when subjected to metallurgical processes, yields only one metal, it is called straight ore.
- **Vein or lode** – It is a crack in the earth's crust filled with mineral.
- **Country rock<vein<orebody<ore<minerals<metals** → Important



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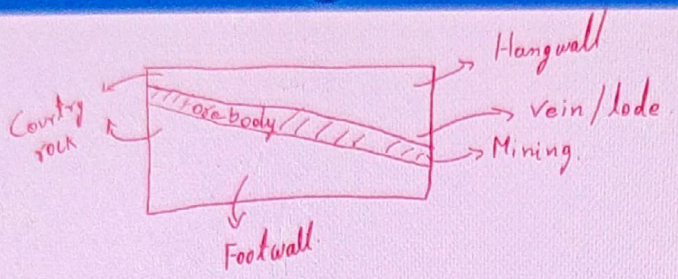
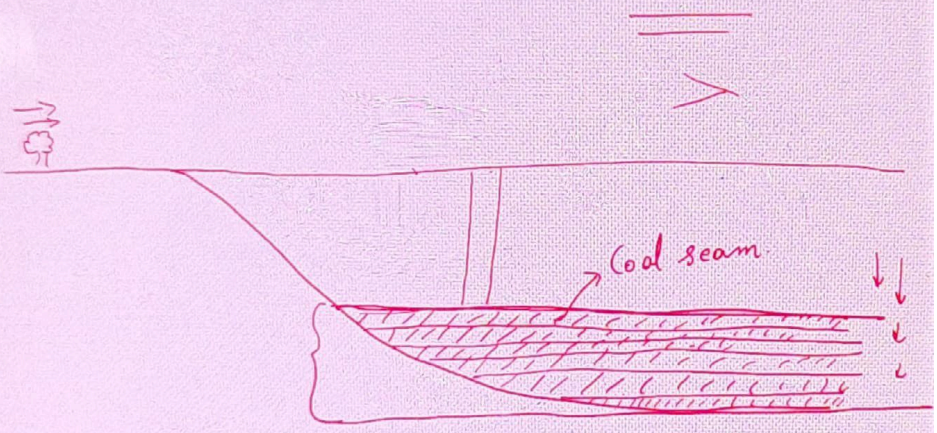
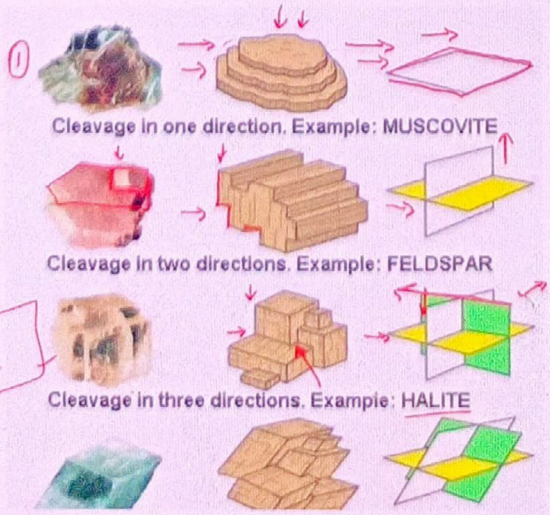


Sedimentary rock.



Physical properties of minerals

- Colour
- Specific gravity
- Lustre
- Streak → Important → Colour of rock in powdered form
  graphite → black streak.
  hematite → cherry red streak.
- Crystalline
- Cleavage
- Fracture
- Hardness



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Physical properties of minerals

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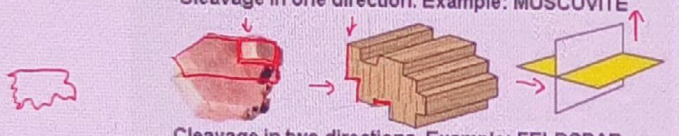
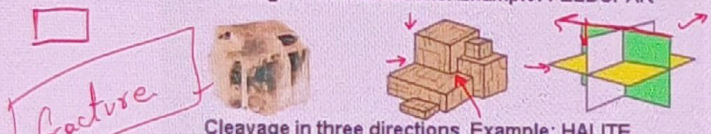
- Hardness

Cleavage in one direction. Example: MUSCOVITE



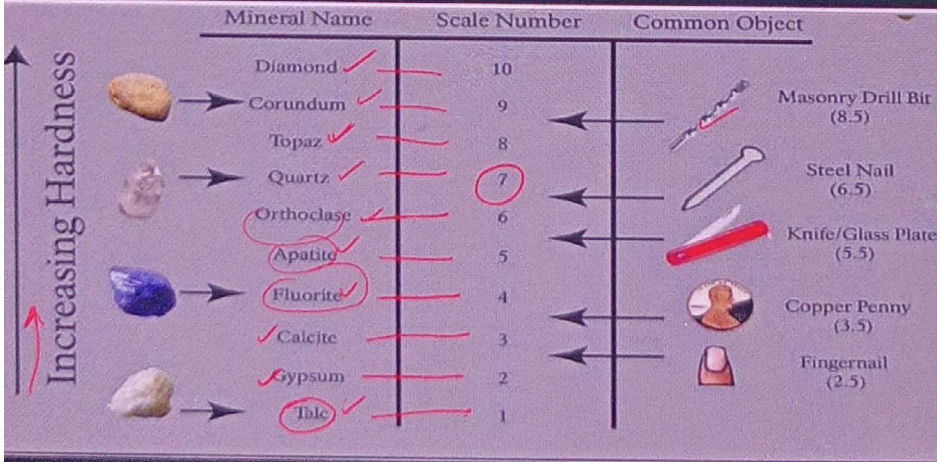
Cleavage in two directions. Example: FELDSPAR



Cleavage in three directions. Example: HALITE

Cleavage in two directions. Example: CALCITE

Mohr's scale of hardness



Protodyakonov strength number

- Hardness of rock is expressed by protodyakonov strength number in Russia.
- The number indicate the relative ease with which a rock can be broken.

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Protodyakonov strength number

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Common minerals

- **Essential minerals –** These make up the bulk of the rocks and are always silicates with the exception of quartz and the carbonates
- **Accessory minerals –** These are present only in small quantities in a rock
- **Secondary minerals –** These are derived from the break down of the others

Rock forming minerals

- Silicates
- Oxides
- Carbonates
- Sulphides
- Sulphates
- Chlorides

8:15 | 24:27 0.59 KB/s

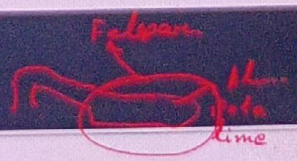
Rock forming minerals

- Silicates
- Oxides
- Carbonates
- Sulphides
- Sulphates
- Chlorides

Silicates

- Felspars
- Mica
- Hornblende and augite
- Olivine

Felspars



- These are all complex silicates of aluminium with potash, soda or lime and are found in igneous rock.
- Potash felspar is also known as orthoclause, it is white, grey or pink in colour with glassy lusture
- On weathering it leaves a hydrated silicate of aluminium known as kaolin or china clay

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Felspars

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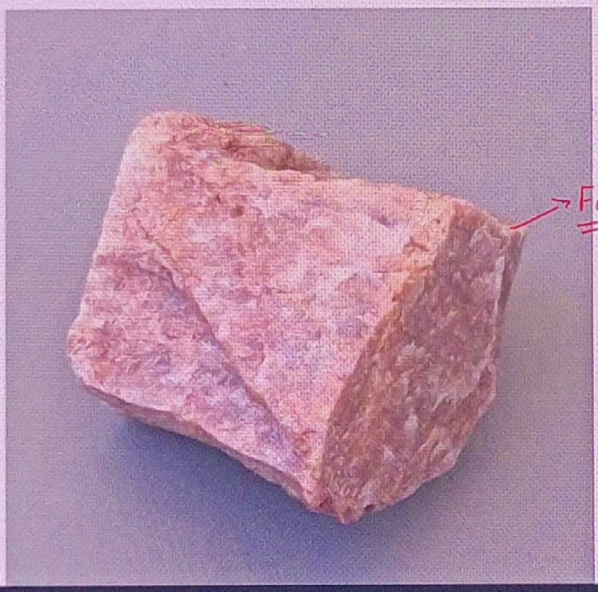
- Potash felspar is also known as orthoclause, it is white, grey or pink in colour with glassy lusture
- On weathering it leaves a hydrated silicate of aluminium known as kaolin or china clay
- The soda and lime felspars are known as plagioclase



Mica

- This occurs as white variety known as muscovite (a silicate of aluminium and potassium) and as black variety known as black mica or biotite (a silicate of aluminium, iron and magnesium)
- The mica can be easily scratched by a finger nail and has a well-developed cleavage.
- It is a common constituent of igneous rocks and crystalline schists (Sp. gr = 2.7 to 3.1; H = 2.5).

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Mica

Hornblende and Augite

- These minerals are complex silicates of calcium, magnesium and iron.
- They are both greenish black in colour.
- Hornblende is also called amphibole.
- It is rather a dull, black mineral, forms six-sided crystals, is found in most igneous rocks and has Sp. gr. 3-3.5; H5 to 6.
- Augite (also called pyroxene) is black but more brilliant than hornblende, forms monoclinic crystals and is found in most of the basic igneous rocks.
- It often alters to chlorite. (Sp. gr. 3 to 3.5; H = 5 to 6).

Hornblende

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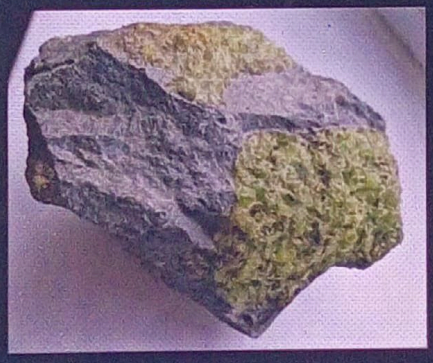
Olivine

- It is also called peridot
- It is a silicate of magnesium and iron found in basic igneous rocks such as dolerite, basalt and periodote.
- It is greenish and looks like quartz (Sp. gr. = - 3.2 to 4; H = 6 to 7).

Olivine Mineral



Oxides

- **Quartz (Silica, SiO_2):** It is an important constituent of the granite and other acid igneous rocks, and a chief constituent of sandstones where it occurs in the broken form (Sp. gr. = 2.6: H = 7).
- **Magnetite (Magnetic oxide of iron, Fe_3O_4):** It is bluish black in colour. Earthy varieties are known as red ochre. The streak is always cherry red (Sp. gr. = 4.5 to 5.3; H = 6).
- **Limonite (Hydrated ferric oxide, $2Fe_2O_3.3H_2O$):** It is amorphous, brown or nearly black in colour and the streak is yellowish brown (Sp. gr. 3.6 to 4; H = 5).
- **Bauxite:** It is essentially a hydrated aluminium oxide ($Al_2O_3.H_2O$), dry white in colour. It results from the decay and weathering of aluminium rocks, often igneous, under tropical conditions. (Sp. gr. 3.5; H = 2.5).

Quartz

Magnetite

Limonite

Bauxite

8:17 26:23 37.6 KB/s 71

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Quartz

Magnetite

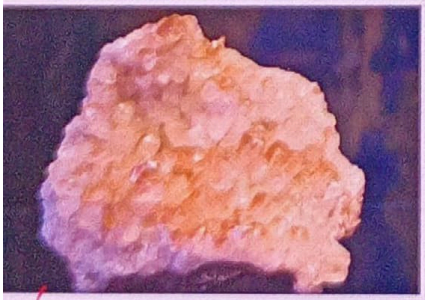
Limonite

Bauxite

@Geolearningpoint

Carbonates

- The common carbonates are of calcium and iron. All carbonates effervesce when treated with dilute hydrochloric acid.
- **Calcite ($CaCO_3$):** It is an essential constituent of marble, chalk or limestone; it is white or colourless and gives a white streak (Sp. gr. = 2.9; H = 3).
- **Siderite ($FeCO_3$):** Colour is brown in various shades and the streak is white (Sp. gr. = 3.7 to 3.9; H = 4).
- **Dolomite:** This is a carbonate of calcium and magnesium, Ca, Mg $(CO_3)_2$ Calcite and dolomite constitute the larger bulk of the limestones, but are sometimes found as secondary minerals in the igneous rocks. (Sp. gr. = 3; H = 4).



Calcite

Siderite

Dolomite

Sulphides

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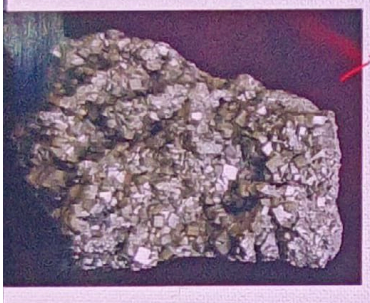
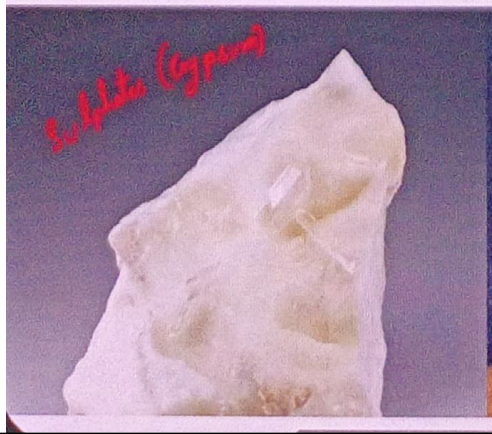
Sulphides

- The common sulphides are the sulphides of iron, lead, zinc and copper.
- **Iron Pyrite (FeS_2):** Brass yellow in colour, this mineral is sometimes found interspersed in a coal seam. e.g. in the Pench Valley Coalfield. The streak is greenished or brownish black. Coal containing iron pyrites is observed to be more liable to spontaneous heating than other coal (Sp. gr. 4.8-5.1; 116 to 6.5).
- **Galena (PbS):** It is grey in colour and has grey streak. (Sp. gr = 7.2 to 7.7; H = 2.5).black.
- **Sphalerite, Blende (ZnS):** It is also known as black jack. It is usually brown or the streak being reddish brown (Sp. gr. = 3.9-4.2; H 3.5-4).
- **Chalcoprite, Copper Pyrite ($Cu_2S.Fe_2S_3$):** It is golden yellow in colour, streak is greenish black (Sp. gr. 4.1, 4.3; H 3.4-4).



Sulphates and Chlorides

- **Sulphates -** Gypsum (Hydrated calcium sulphate, $CaSO_4.2\ H_2O$): It forms colourless crystals, but some varieties may be white or grey. Plaster of paris is made from gypsum by heating it or expel some of its water of crystallisation and then grinding it to a fine powder (Sp. gr. 2.3; H=2).
- **Chlorides -** Rock Salt (known as common salt, NaCl): It is colourless or white when pure (Sp. gr. = 2.2; H = 2).



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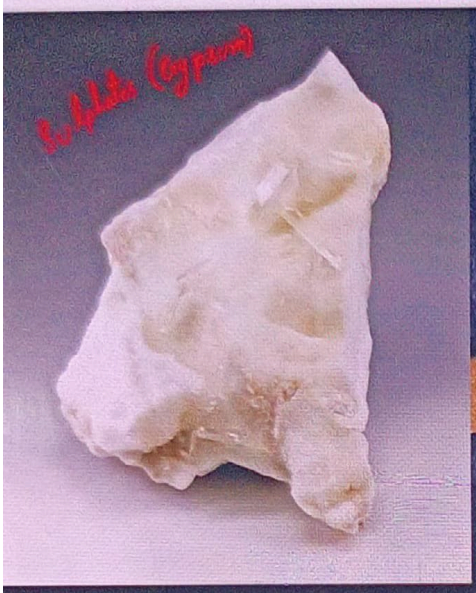
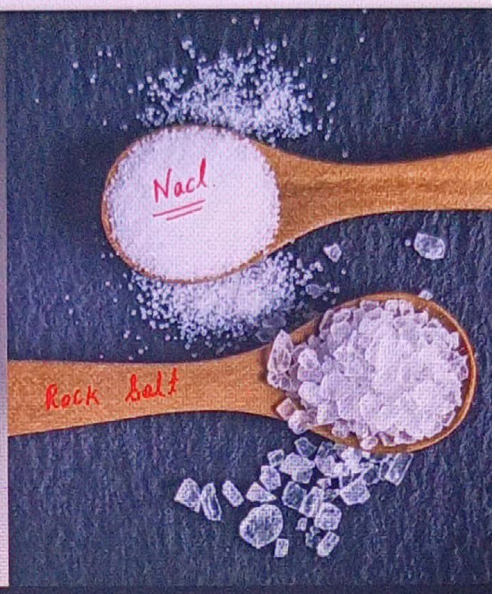
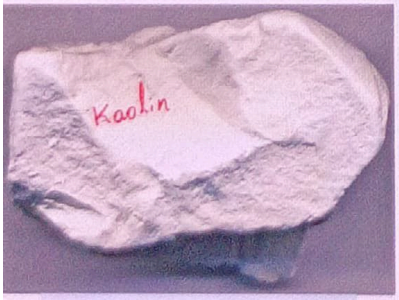




Other rock forming minerals

- **Kaolin (also called China clay, $Al_2O_3.2SiO_2.2H_2O$):** It may be described as hydrated silicate of aluminium. It is a soft, white, calyey material crumbling to powder when pressed between fingers. Felspars when decomposed yield china clay.
- **Fireclay:** Any clay or shale that does not fuse below 1580°C is called fireclay. Thepredominant constituent of these clays is the mineral kaolinite with the formula $Al_2O_3.2SiO_2.2H_2O$. Besides aluminium and silica the fireclay also contains oxides of iron, calcium, magnesium, sodium and potassium.
- **Fluorspar: (CaF_2):** It may be colourless, purple, green or yellow; lustre is vitreous but often transparent. It occurs in veins of metalliferous ores with galena (Sp. gr. = 3; H = 4).
- **Baryte ($BaSO_4$):** It may be white, yellow, red or blue with a vitreous lustre and is commonly found in mineral veins associated with the ores of lead and zinc. (Sp. gr. = 4.5; H = 3).



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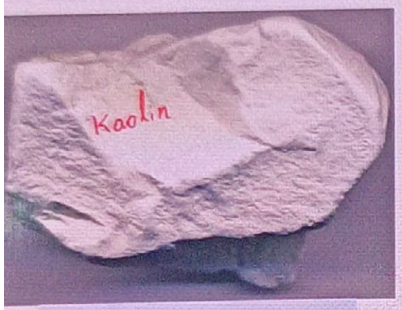

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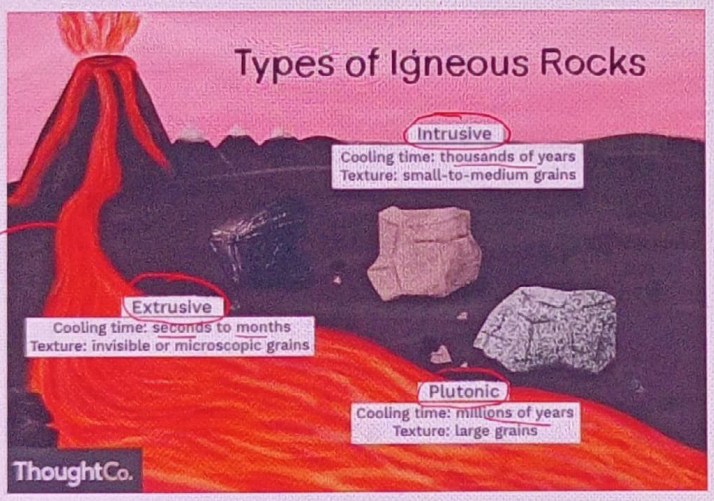
- **Uranium oxides:** Uranium is the metal used for production of nuclear energy. Two uranium isotopes U-235 and U-233 are fissionable materials. Uranium ore contains 0.03 to 0.1% of uranium. The mined ore is processed to give a marketable concentrate containing 75% UO
- **Rare Earth Metals:** This is a group of metals which includes metals like cerium (Ce), lanthanum, erbium, yittrium and others. Thorium is closely associated in nature with this group. Thorium is a metal related to titanium and has a sp. gr. of 11. Monazite is a phosphate of cerium metals, but is industrially important as a source of thorium compounds as it contains small percentage of thorium oxide or thorium silicate. Monazite: (Sp. gr. 5.27; H = 5:5)

8:19 | 28:59 1.47 KB/s 71

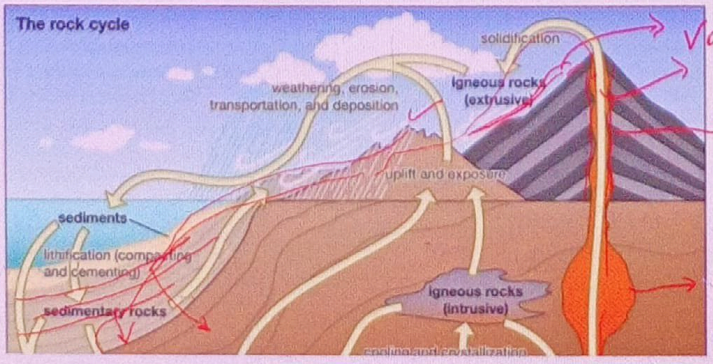
Rocks

- Igneous Rocks – The rocks that have consolidated near the surface of the earth from molten material called magma
- Sedimentary Rocks – Those produced chiefly by the breaking up of pre-existing rocks and deposition of the broken material in the form of layers
- Metamorphic Rocks – Those produced from pre-existing rocks by the action of high temperatures and pressures

Magma



Lava



Volcanic

Volcano Neck

Hypabassa

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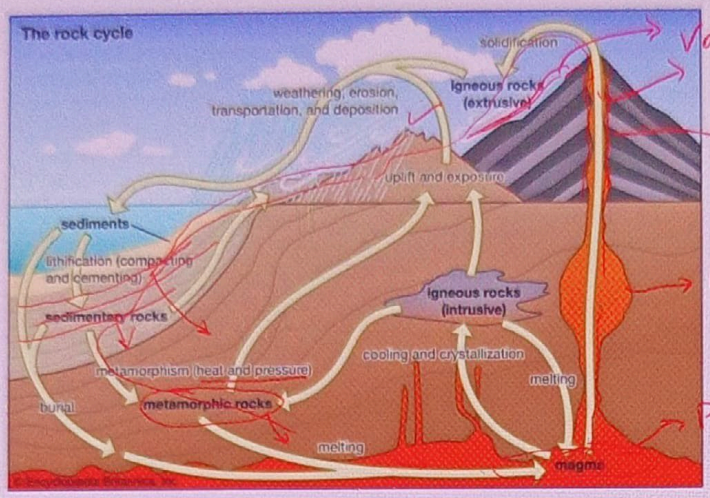

Rocks formed of magma

- It depends on the rate and place of cooling
- Plutonic – The rocks which are cooled at depths had very slow rate of cooling resulting in large coarse crystals.
- Hypabyssal – Those that cooled at intermediate depths had a faster rate of cooling yielding smaller size crystals.
- Volcanic – Those that cooled at or very near the surface had a fast rate of cooling yielding no crystals but nearly glassy texture and are called volcanic.

Geological disturbances

- Dyke
- Sill
- Fault
- Washout
- Roll
- Fold
- Splitting of seam
- Slips

Dyke

- It is a more or less parallel sided vertical wall of igneous rock formed due to upward intrusion of molten magma generally through fissure or cracks extending in the previous rocks.
- Dyke cause interruption in mining operations and make mechanised mining difficult.
- They also create strata control problems.
- Drilling and blasting to cross hard material of

8:21 | 30:17 0.13 KB/s 4G 70

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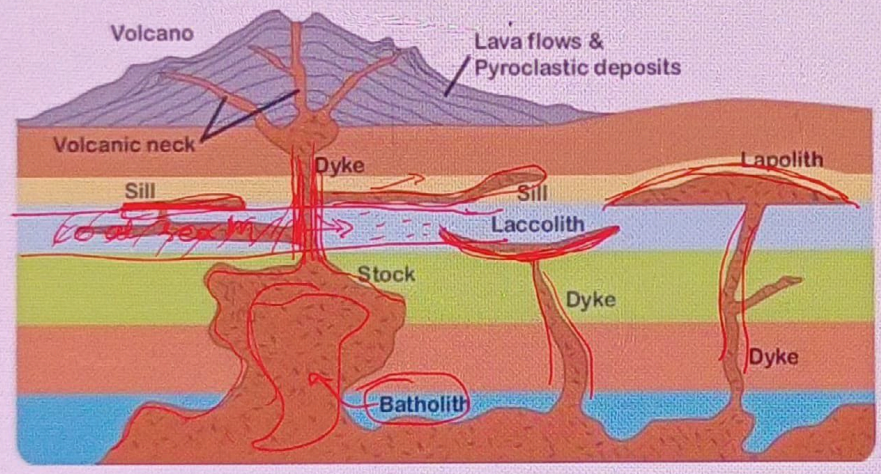
- Drilling and blasting to cross hard material of jhama is a costly affair.



Sill

- Sill is a sheet of igneous rock spreading in bedding planes in stratified rocks.
- It may cut across and go from one to another bedding plane.
- A sill may be a few centimetres to several metres thick and may cover large areas.
- A sill is connected with dyke at some or the other place through which the hot magma has come and spread.
- Sills are of hard stone (dolerite or mica-peridotite).
- A sill at top of a coal seam forms a very strong roof which is difficult to cave and may result into an air blast when a large over-hanging goaf suddenly falls.

Fault

- A fault is a fracture in rocks usually associated with lateral or vertical displacement of the fractured beds. Faults occur when strength of rocks is insufficient to withstand stress due to

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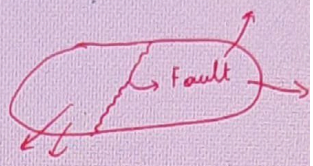
Fault

- A fault is a fracture in rocks usually associated with lateral or vertical displacement of the fractured beds. Faults occur when strength of rocks is insufficient to withstand stress due to movements inside the earth.



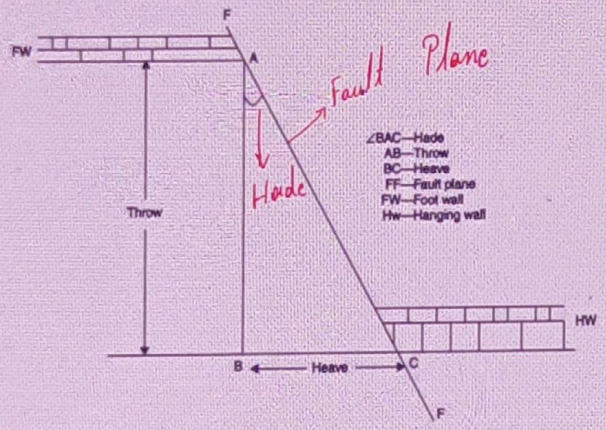
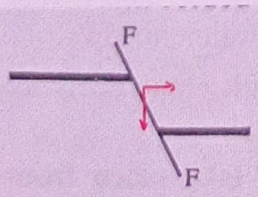


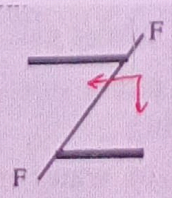
Fig. 4.25 *Parts of a fault*

Types of fault

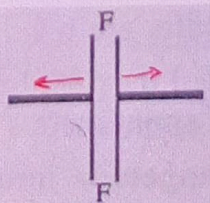
- Normal fault: Fault in which ends of broken strata move away (do not overlap) is called normal fault. Normal faults occur in areas of tension in the strata. Such faults are commonly found in Indian mines.
- Reverse fault: Fault in which the older rocks are thrust over the new ones by lateral compression so that ends of the broken strata overlap each other is called reverse fault. Reverse faults occur when the strata are compressed into a space less than their original extension.
- Trans-current fault: Fault in which the broken ends of 10 strata remain in the same level but move away from each other is called trans-current fault. Such faults are also found in folded strata.



Normal fault
(broken ends do not overlap)



Reverse fault
(broken ends overlap)



Trans-current fault
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Types of fault

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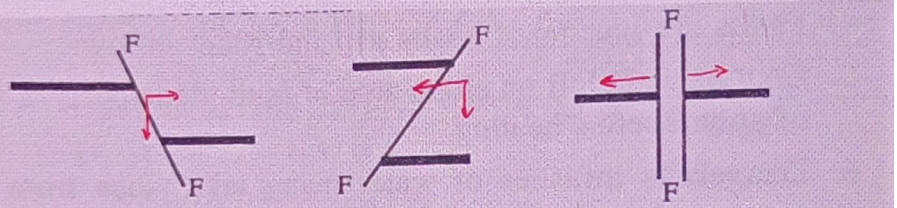
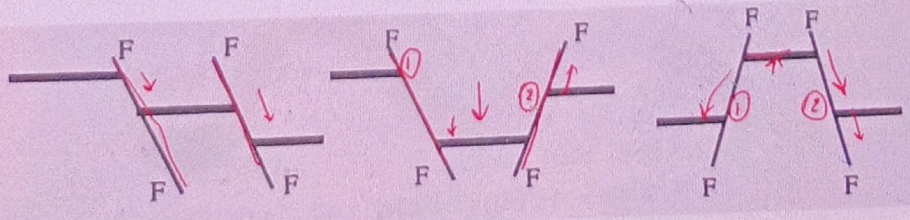


Normal fault (broken ends do not overlap)

Reverse fault (broken ends overlap)

Trans-current fault (broken ends move away inthe same level)

- At some places several faults are met one after the other in the form of steps. Such faults are called step faults.
- If a down-throw fault is followed by an up-throw fault, a trough is formed. Such group of faults is known as trough fault.
- If an up-throw fault is followed by a down-throw fault, a ridge fault is formed.



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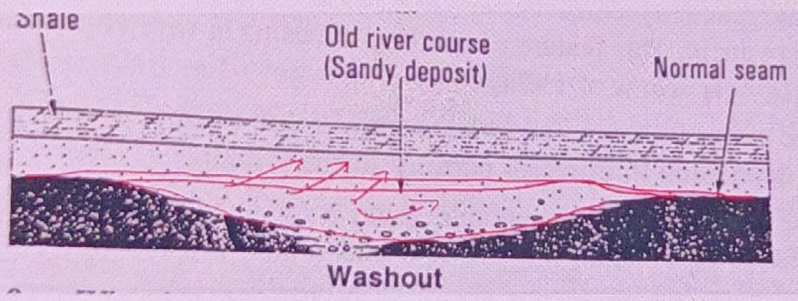
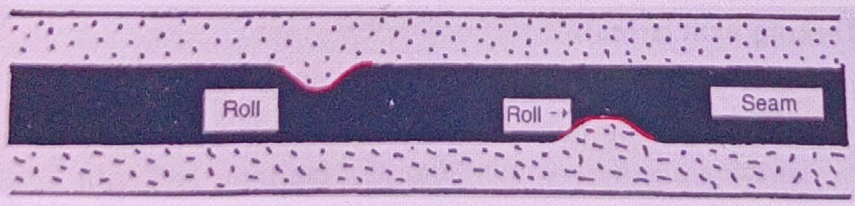
Slips

- Slips are small but clear cut fractures, sometimes slickensided (polished), occurring often in groups. They are often covered with layers of carbonate mineral making the roof liable to fall suddenly without indication.

Washouts and rolls

- A wash out is an irregularity causing local thinning of coal seam or its entire disappearance, generally due to erosion by a river or stream. The eroded portion is filled up with coarse sediments.
- Sudden thinning causes problems in mining. Loose roof rocks(sediments) present problems in support.
- Rolls - Undulations in a coal seam which may be due to local and minor flexures or features associated with wash outs are known as rolls.





Pothole

- Pothole is a well like surface subsidence, formed by flowing away of sandy or soft strata material into u.g. workings or goaf.
- Its depth may be 40-45m.
- Potholes are generally formed when u.g. workings below weak/ sandy strata are advanced towards a fault and there is accumulation of water on surface.
- Water reduces the strength of soft strata and results in subsidence.
- If pothole occurs within HFL area of a river/nalla or an accumulation of rain water on surface, it may inundate the mine.
- Potholes have occurred in several mines like Majree, Bada Dhemo, Korba, Surakachar, Lachhipur, Khas Kajora, Sarpi Kajora, Mahabir, Ballarpur etc.
- To prevent occurrence of potholes, DGMS does not grant permission for working when thickness of hard OB is less than 7.5m.
- Subsidence area is blanketed and consolidated from time to time and steps are taken to prevent accumulation of water in subsidence area.

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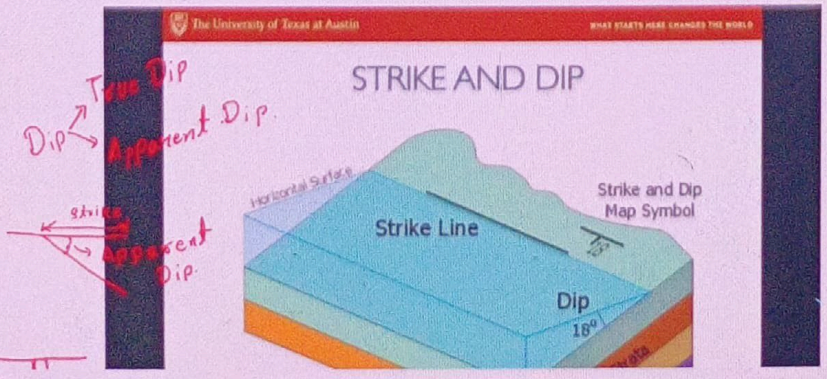
- Subsidence area is blanketed and consolidated from time to time and steps are taken to prevent accumulation of water in subsidence area.
- In shallow workings, large pillars are made and gallery height and width kept limited. Workings are supported heavily.
- Where possible, surface nalla or jore is diverted

Dip and strike

- Inclination of a coal seam or strata from the horizontal is known as dip.
- The maximum dip is called true dip.
- Dip is described in degrees, such as 40°, 50°, or more commonly in 1 in 4, 1 in 5 etc.
- Dip in a direction other than the true dip direction is known as apparent dip.
- The dip at 90° to the true dip direction of coal seam or strata is 0°.
- This direction is known as strike direction.
- In the strike direction, the coal seam or strata is found level.



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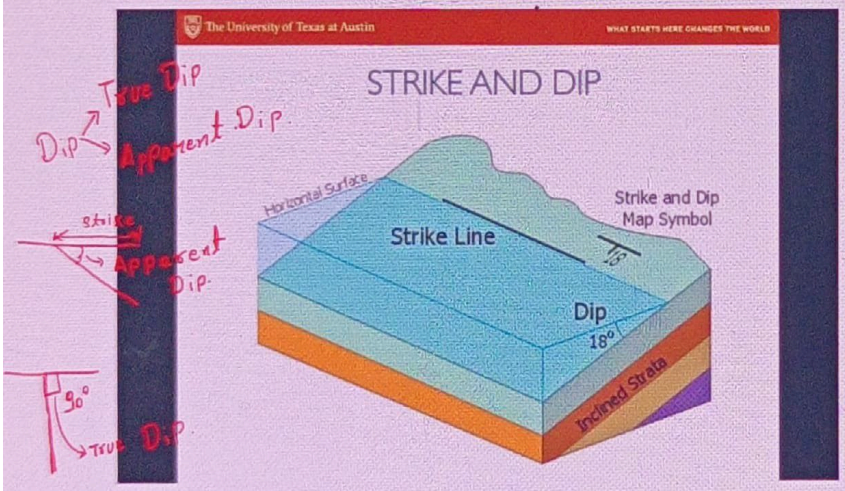
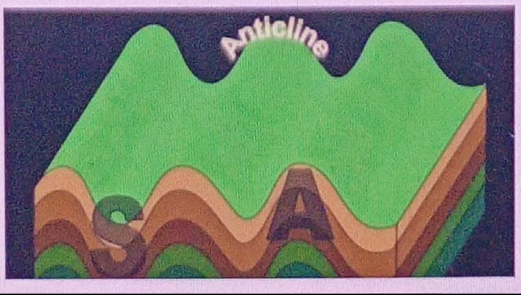


Composition and classification of igneous rocks

- Silica more than 65% - Acid rock
- Silica 55% to 65% - Intermediate rock
- Silica 45% to 55% - Basic rock
- Silica less than 45% - Ultra basic rock



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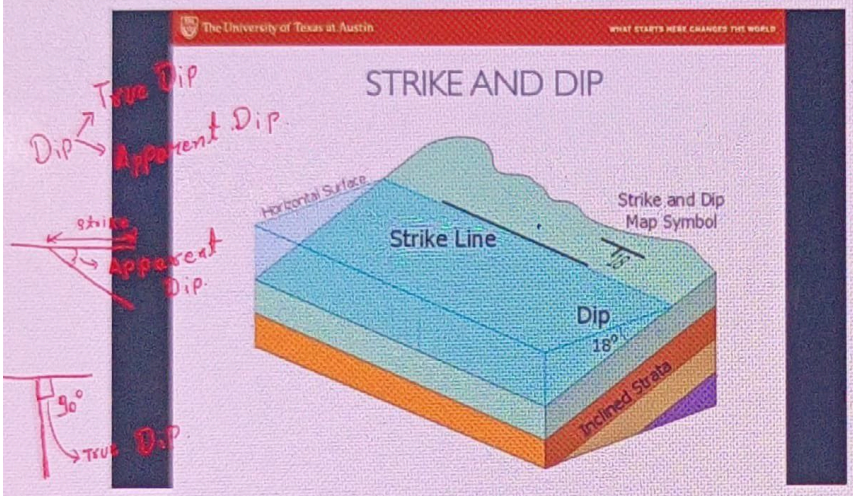

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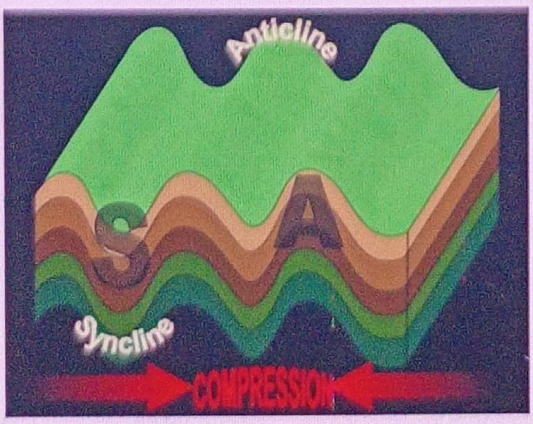

Formation of ore deposits

- Magmatic segregation
- Pegmatites
- Pneumatolytic ore deposits
- Hydrothermal ore deposits
- Metasomatic ore deposits
- Sedimentary origin
- Placer deposits
- Gossan
- Evaporation

Magmatic Segregation

- Magma is the original source of most of the minerals
- The magma which is chemically very reactive due to pressure, temperature and composition of various minerals dissolves adjacent rocks through which it travels, giving rise to new minerals.
- Minerals having nearly similar fusion points segregate and concentrate together resulting in magmatic segregation.
- Important deposits of metallic oxides such as magnetite and limentite, and sulphides such as pyrrohtite and chalcopyrite are formed in this way.
- Most of the ferromagnesium silicates and other oxides are formed at depth by magmatic segregation

Pegmatites

- After deposition of minerals by the process of magmatic segregation the magma is fluid and has a concentration of volatile constituents, i.e. various gases and vapours.
- Cooling of the liquid portion results in the formation of pegmatites.
- Pegmatites enters in the pre-existing rocks forming dykes and veins.
- Economic deposits of minerals like felspar, quartz, mica, beryl and aptite are formed in this way.
- Eg. Girdih, Hazaribagh (Bihar), Bhilwara (Rajasthan), etc.

Pneumatolytic ore deposits

- The magmatic segregation and formation of pegmatites leaves the residual magma very fluid and it contains heated gases of great chemical activity.
- These gases penetrate the adjacent country rock and by their reaction with the latter form mineral deposits.
- Such deposits are known as pneumatolytic ore

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- Examples are cassiterite deposits.

Hydrothermal ore deposits

- During the final stage of consolidation of magma, its aqueous solutions which consists of heated waters of great chemical activity deposit their mineral load.
- These aqueous solutions, because of their fluidity, are capable of travelling long distances from their parent source.
- The ore deposits formed by such aqueous but highly fluid solutions of magma are known as hydrothermal ore deposits.
- The term also covers deposits formed by descending surface waters which sometimes leach away valuable constituents of existing rocks and precipitate their load of minerals in the cracks, fissures and cavities in the earth's crust

Metasomatic ore deposits

- Surface waters passing down into the fissures and cracks in the earth sometimes carry minerals in solution or suspension derived during their passage over a variety of rocks.
- The heat beneath the earth's surface renders such descending circulating waters chemically active and sometimes the minerals of pre-existing rocks are replaced, partially or completely, by minerals of the circulating waters, particle by particle.
- The structure of the pre-existing rock may remain unaltered. The ore deposits so formed are called metasomatic ore deposits.
- Some deposits of chlorite, serpentine, and chalcopyrite have been formed in this way.

Metamorphism

- The process of metamorphism which results in the formation of metamorphic rocks may generate enough heat and pressure to alter existing mineral deposits of impure or low- grade ores into comparatively more pure and valuable minerals.
- Some banded hematite formations have changed to banded magnetite-quarzite rocks in Salem and Tiruchirapalli districs by metamorphism.
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- Another example of heat changing pre-existing mineral into a more pure mineral is offered by the conversion of bituminous coal into anthracite in the vicinity of dykes and sills in some cases.
- Sillimanite ($Al_2O_3\ SiO_2$) in Assam and eastern Maharashtra (Bhadara district)and kyanite (Al_2O_4, SiO_2) are formed by metamorphism.
- Talc, hydrated magnesium silicate, is also a product of metamorphism of magnesium bearing rocks like dolomite, e.g. near Jaipur in Rajasthan.

Sedimentary origin

- Some mineral deposits are of sedimentary origin and the deposits of sediment may be formed organically as in the case of coal deposits, or chemically, as in the case of some limestone or chalk deposits.
- Such deposits are always bedded and stratified.

Placer deposits

- Alluvial, detrital or placer depositer are formed by breaking up of the parent rock and subsequent tranporation of the mineral particles by stream or wave action.
- The minerals are found in sizeable concentration where the velocity, and hence the carrying power of the currents, is decreased.
- In such deposits the minerals are concentrated into fractions according to their specific gravities and two or more minerals of similar sp. gr. may be found together.
- Examples of such placer deposits are gold placers, with the gold being associated magnetite, chromite, etc. Alluvial, gem deposits, platinum, tin and worfram are some other examples of alluvial or placer deposits.
- Laterite deposits are formed by the leaching away of soluble minerals leaving behind in the laterite a valuable ore such as nickel or bauxite.
- Thus these are normally surface deposits.

Gossan

- Ore deposits which outcrop at the surface undergo weathering in the outcrop zone and may decompose.
- The weathered upper part the deposits is known as gossan.
- The gossan is usually an oxidised zone which may sometimes change into carbonates.
- Thus a vein of galena at depth may consist of cerussite ($PbCO_3$) in the gossan.
- Copper sulphide of chalcopyrite (Cu_2S, Fe_2S_3) which may occur in a vein at depth changes into malachite, $CuCO_3\ Cu(OH)$, in the gossan, e.g. at Khetri in Rajasthan, Concentration of minerals takes place in the gossan as the lighter or less stable minerals are washed away by percolating waters during weathering.

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- Rich mineral deposits of economic value, therefore, occur as a cap over low-grade ore.

Evaporation

- Evaporation of water from solutions containing minerals is a familiar example of one process of mineral formation, e.g. common salt produced by evaporation of enclosed sea water.

Mode of occurrence of minerals

- Minerals are usually found in ores.
- the term ore is used to describe an accumulation of any mineral mixed with other elements.
- The mineral content of the ore must be in sufficient concentration to make its extraction commercially viable.

Minerals occurs in forms of:

- In igneous and metamorphic rocks minerals may occur in the cracks, crevices, faults or joints.
- The smaller occurrences are called veins and the larger are called lodes.
- In most cases they are formed when minerals in liquid/molten and gaseous forms are forced upward through cavities towards the earths surface.
- Major metallic minerals like tin, copper, zinc and lead

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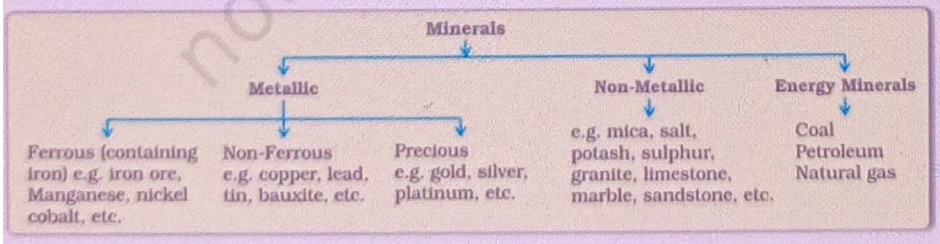
- In sedimentary rocks a number of minerals occur in beds or layers. They have been formed as a result of deposition, accumulation and concentration in horizontal strata. Coal and some forms of iron ore have been concentrated as a result of long periods under great heat and pressure. Another group of sedimentary minerals include gypsum, potash salt and sodium salt. These are formed as a result of evaporation especially in arid regions.
- Another mode of formation involves the decomposition of surface rocks, and the removal of soluble constituents, leaving a residual mass of weathered material containing ores. Bauxite is formed this way.

CLASSIFICATION OF MINERALS



- Certain minerals may occur as alluvial deposits in sands of valley floors and the base of hills. These deposits are called 'placer deposits' and generally contain minerals, which are not corroded by water. Gold, silver, tin and platinum are most important among such minerals.
- The ocean waters contain vast quantities of minerals, but most of these are too widely diffused to be of economic significance. However, common salt, magnesium and bromine are largely derived from ocean waters. The ocean beds, too, are rich in manganese

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- Sedimentary rocks on the western and eastern flanks of the peninsula, in Gujarat and Assam have most of the petroleum deposits.

Ferrous Minerals

- Iron ore
  - Magnetite is the finest iron ore with a very high content of iron up to 70 per cent. It has excellent magnetic qualities, especially valuable in the electrical industry.
  - Hematite ore is the most important industrial iron ore in terms of the quantity used, but has a slightly lower iron content than magnetite (50-60 per cent).
  - In 2018–19 almost entire production of iron ore (97%) accrued from Odisha, Chhattisgarh, Karnataka and Jharkhand. The remaining production (3%) was from other states.

Major iron ore belts

- **Odisha-Jharkhand belt:** In Odisha high grade hematite ore is found in Badampahar mines in the Mayurbhanj and Kendujhar districts. In the adjoining Singbhum district of Jharkhand haematite iron ore is mined in Gua and Noamundi.
- **Durg-Bastar-Chandrapur belt** lies in Chhattisgarh and Maharashtra. Very high grade hematites are found in the famous Bailadila range of hills in the Bastar district of Chhattisgarh. The range of hills comprise of 14 deposits of super high grade hematite iron ore. It has the best physical properties needed for steel making. Iron ore from these mines is exported to Japan and South Korea via Vishakhapatnam port.
- **Ballari-Chitradurga-ChikkamagaluruTumakuru belt** in Karnataka has large reserves of iron ore. The Kudremukh mines located in the Western Ghats of Karnataka are a 100 per cent export unit. Kudremukh deposits are known to be one of the largest in the world. The ore is transported as slurry through a pipeline to a port near Mangaluru.
- **Maharashtra-Goa belt** includes the state of Goa and Ratnagiri district of Maharashtra. Though, the ores are not of very high quality, yet they are efficiently exploited. Iron ore is exported through Marmagao port.

Ferrous minerals

- Manganese
  - Manganese is mainly used in the manufacturing of steel and ferro-manganese alloy.
  - Nearly 10 kg of manganese is required to manufacture one tonne of steel.
  - It is also used in manufacturing bleaching powder, insecticides and paints.

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Non Ferrous Minerals

- Copper
  - India is critically deficient in the reserve and production of copper.
  - Being malleable, ductile and a good conductor, copper is mainly used in electrical cables, electronics and chemical industries.
  - The Balaghat mines in Madhya Pradesh, Khetri mines in Rajasthan and Singhbhum district of Jharkhand are leading producers of copper.

Bauxite

- Though, several ores contain aluminium, it is from bauxite, a clay-like substance that alumina and later aluminium is obtained.
- Bauxite deposits are formed by the decomposition of a wide variety of rocks rich in aluminium silicates.
- Aluminium is an important metal because it combines the strength of metals such as iron, with extreme lightness and also with good conductivity and great malleability.
- India's bauxite deposits are mainly found in the Amarkantak plateau, Maikal hills and the plateau region of Bilaspur-Katni.

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- Odisha was the largest bauxite producing state in India in 2016-17. Panchpatmali deposits in Koraput district are the most important bauxite deposits in the state.

Non Metallic Minerals

- Mica is a mineral made up of a series of plates or leaves. It splits easily into thin sheets. These sheets can be so thin that a thousand can be layered into a mica sheet of a few centimeters high. Mica can be clear, black, green, red yellow or brown. Due to its excellent di-electric strength, low power loss factor, insulating properties and resistance to high voltage, mica is one of the most indispensable minerals used in electric and electronic industries.
- Mica deposits are found in the northern edge of the Chota Nagpur plateau. Koderma Gaya – Hazaribagh belt of Jharkhand is the leading producer.
- In Rajasthan, the major mica producing area is around Ajmer. Nellore mica belt of Andhra Pradesh is also an important producer in the country.

Rock Minerals

- Limestone is found in association with rocks composed of calcium carbonates or calcium and magnesium carbonates.
- It is found in sedimentary rocks of most geological formations.
- Limestone is the basic raw material for the cement industry and essential for smelting iron ore in the blast furnace.

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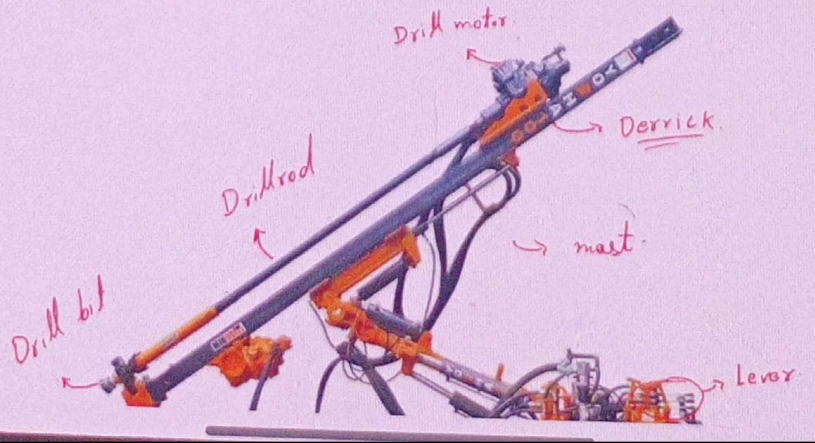
Application of geology in mining

- Geology plays a fundamental role in various aspects of mining, providing crucial information and insights throughout the mining lifecycle. Some key applications of geology in mining include:
- **Exploration**- Geologists use their understanding of geological processes, rock formations, and structures to identify areas with potential mineral deposits. They employ techniques such as geological mapping, geochemical analysis, geophysical surveys, and remote sensing to locate promising sites for further exploration.
- **Resource Estimation**- Once a potential deposit is identified, geologists assess its size, grade, and economic viability through resource estimation. This involves collecting and analyzing geological data to determine the quantity and quality of the mineral resource. Geostatistical methods are often employed to model the distribution of minerals within the deposit.
- **Deposit Modelling**- Geologists create detailed models of mineral deposits based on their understanding of geological formations and mineralization processes. These models help mining engineers plan the most efficient and cost-effective methods for extracting the minerals while minimizing environmental impact.
- **Mining Planning and Design**- Geologists collaborate with mining engineers and other professionals to develop mining plans and designs that optimize the extraction of minerals. They provide input on the geological characteristics of the deposit, including its structure, rock mechanics, and ore variability, which influence mining methods, equipment selection, and mine layout.
- **Grade Control**- Geologists monitor the quality and distribution of ore during mining operations to ensure that extraction is conducted in accordance with the planned mining sequence. They collect and analyze samples from drilling, blasting, and excavation activities to assess ore grade and provide feedback for adjusting mining strategies in real-time.
- **Environmental Management**- Geologists contribute to environmental management efforts by assessing the potential environmental impacts of mining activities and developing strategies to mitigate them. They study the geological setting to identify sensitive ecosystems, geological hazards, and groundwater resources that may be affected by mining operations.
- **Mine Closure and Rehabilitation**- Geologists play a role in mine closure and rehabilitation by evaluating post-mining landforms, assessing the potential for environmental contamination, and recommending measures for site restoration. They utilize their understanding of geological processes to facilitate the natura recovery of ecosystems and ensure the long-term sustainability of the area.
- Overall, geology serves as a cornerstone of the mining industry, guiding exploration, resource evaluation, extraction, and environmental stewardship to maximize the benefits of mineral resources while minimizing adverse impacts on the environment and surrounding communities.

Methods of drilling

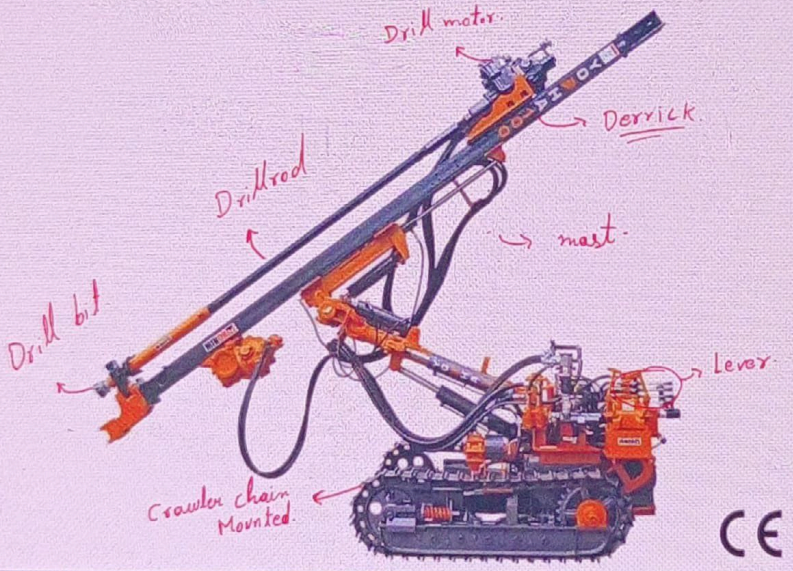
- Percussive drilling
- Rotary drilling
- The percussive method is further sub-divided as
  - Drilling by rigid rods
  - Rope drilling, also known as cable drilling or churn drilling.
- The rotary method may be used with a view to get a core of the rocks passed through or simply to drill a hole, and this decides the type of drilling tool used.
- The rotary method is subdivided as
  - Drilling by saw toothed cutter
  - Drilling by tri-cone rock roller bit
  - Drilling by diamond drill bit
  - Drilling by chilled shots.



adverse impacts on the environment and surrounding communities.

Methods of drilling

- Percussive drilling
- Rotary drilling
- The percussive method is further sub-divided as
  - Drilling by rigid rods
  - Rope drilling, also known as cable drilling or churn drilling.
- The rotary method may be used with a view to get a core of the rocks passed through or simply to drill a hole, and this decides the type of drilling tool used.
- The rotary method is subdivided as
  - Drilling by saw toothed cutter
  - Drilling by tri-cone rock roller bit
  - Drilling by diamond drill bit
  - Drilling by chilled shots.



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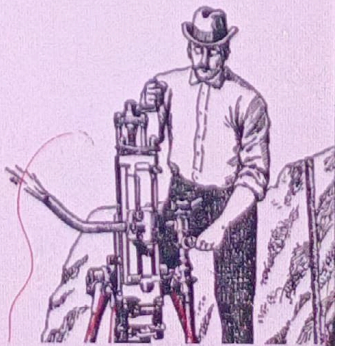
Percussive drilling

- In this method which is the oldest one of drilling, the hole is drilled by striking a number at short in intervals on the rock by a chisel-type tool and between the blows the tool is rotated slightly.
- The rock is chipped away with each blow and a circular hole is formed.
- During drilling the chisel is suspended from the surface by rods or wire rope and the weight of the chisel, rods, etc. is utilised to give the striking force.
- Drilling with rods - The rods are Ni-Cr or carbon steel.
- Each rod has a male screw at one end and a female -screw (screwed socket) at the other.
- For soft surface deposits which consists of alluvium, clay auger and worm auger may be used. These are given a rotary rather than a percussive motion.
- The straight chisel is commonly used for hard strata and the V chisel and T chisel, for very hard strata.
- Derrick is used chiefly for lifting the rods from the hole.



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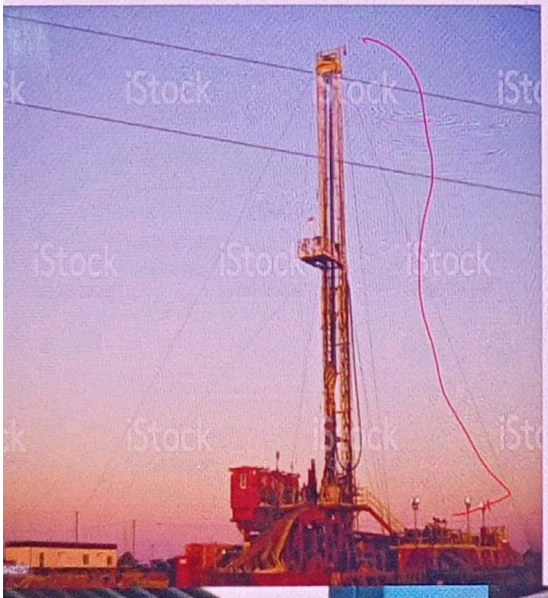

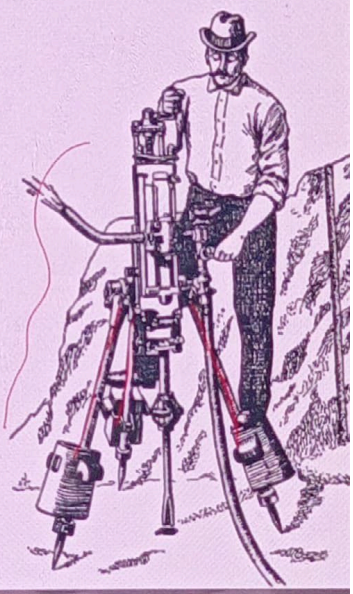

Manual drilling

- The drilling rods are given a percussive motion with the help of a corking level to which they are attached through a stirrup and a brace-head.
- A brace-head is simply a pair of crossed handles fixed to the end of a short top rod.
- Two or three men press down the free end of the rocking lever thereby lifting the rods while one man turns them slightly by means of the brace head.
- The men then let go the free end so that the rods fall and the drilling tool gives a blow on the rock.
- Water is poured in the hole at intervals and the process is repeated.
- Short rods are added till the depth drilled by such small rods is slightly more than the length of full-length rod and the short rods are then replaced by a full-

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- Water is poured in the hole at intervals and the process is repeated.
- Short rods are added till the depth drilled by such small rods is slightly more than the length of full-length rod and the short rods are then replaced by a full-length rod.
- **Retaining key:-** It is a device used at the time of raising or lowering the rods of square cross section.
- **Bulldog safety clamp:-** It is a device used for raising and lowering of circular cross section rods.

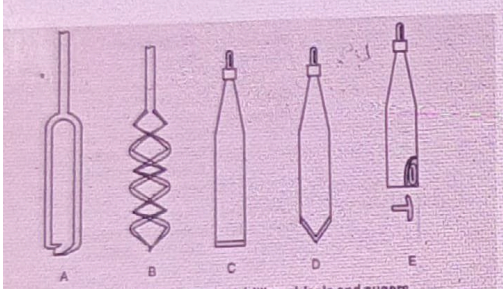
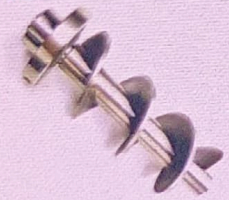
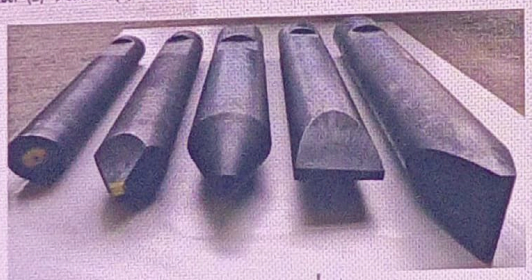
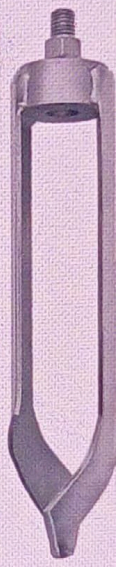
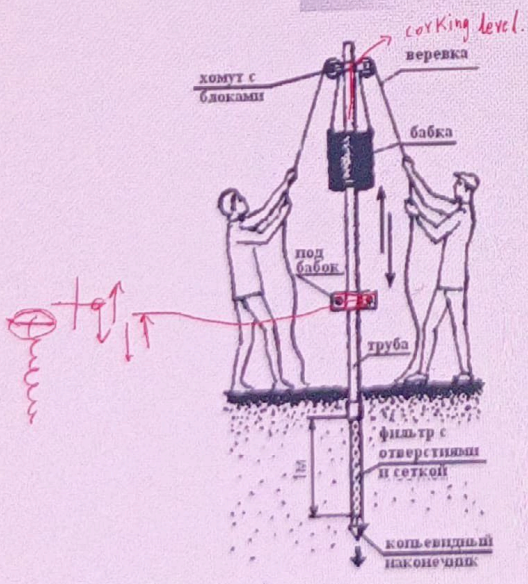


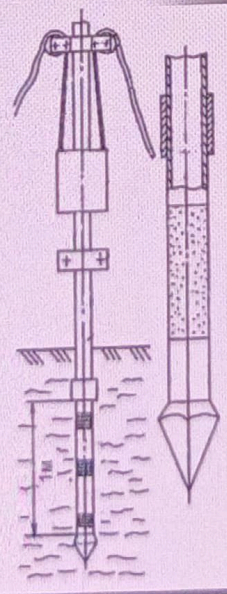
Fig. 3.1 Common types of drilling chisels and augers.
(A) Clay auger (B) Worm auger (C) Straight chisel (D) V-chisel (E) T-chisel











Sludger

- During drilling the bottom of the hole soon gets filled with cuttings and has to be cleaned out frequently.
- This is done with the help of a sludger which consists of a long cylinder or pipe, open at the top and with a flap valve at its lower end.
- The flap valve opens upwards.
- When attached to the end of the rods and worked up and down the sludger gets filled with the sludge.
- It is then withdrawn to the surface and the process repeated till

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- The flap valve opens upwards.
- When attached to the end of the rods and worked up and down the sludger gets filled with the sludge.
- It is then withdrawn to the surface and the process repeated till the hole is cleaned.
- The cuttings brought to the surface in the sludger give an indication of the rock being drilled.
- The bottom of the drill hole is always kept full with water during drilling

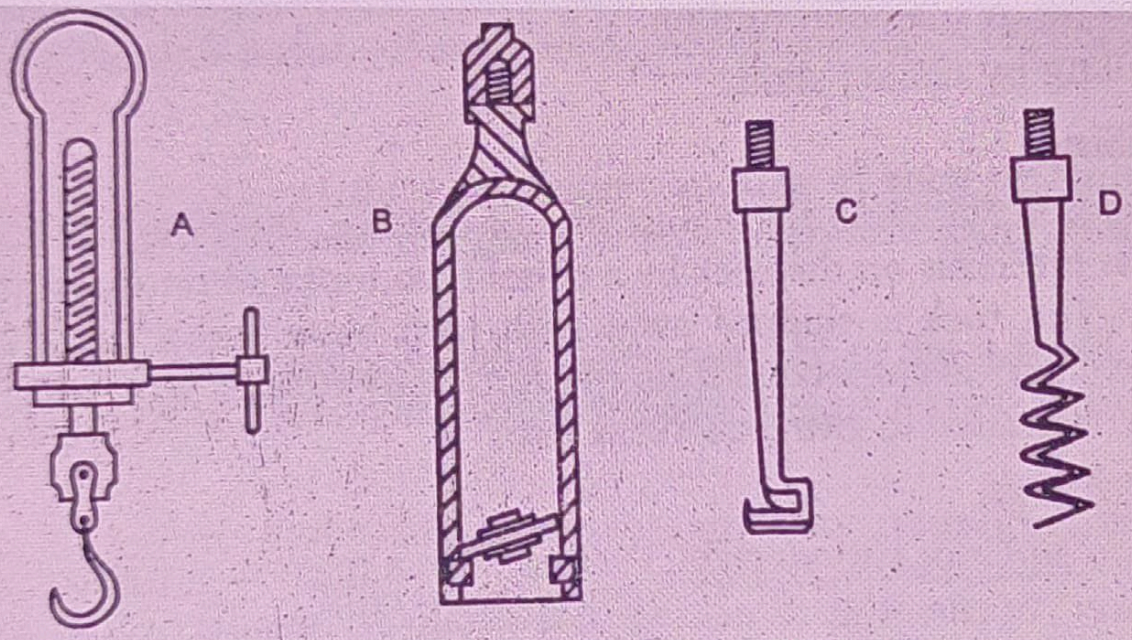

Fig. 3.2. (A) Stirrup and screw. (B) Sludger (C) Crow's foot (D) Sprial worm

Fishing the borehole

- Devices like the crows foot and the spiral worm may be used to catch the broken rod under a joint in the borehole
- Broken pieces of chisel are sometimes raised with the help of powerful magnets
- In diamonds drilling, described later, the diamonds sometimes become loose and fall in the hole.
- The operation of tracing the broken and lost parts in the hole and withdrawing them to the surface is known as ***fishing the borehole***

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known as *fishing the borehole*

Lining a drill hole

- During drilling a steel pipe is used for lining the drill hole from surface upto the hard rock, and the drilling tool and rods pass through the pipe.
- Obviously, the length of the drill-hole upto which the lining pipe has to be fitted should be of a larger diameter.
- The lining pipe is generally withdrawn after the hole is completed though it may sometimes be necessary to leave it in its position to prevent caving of sides, e.g. drill hole for stowing, water pipes, etc.
- The lining is done by hammering first a special steel pipe with a cutting edge. Pipes of 6m lengths and having screwed joints are added to that pipe.

Power drilling with rods

- Drilling with manual labour without the help of power is suitable for holes upto 150 mm in diameter and upto a depth of 30 m or so.
- Beyond that depth, it is impossible to drill with the use of power from a diesel or petrol engine
- Vertical boilers have sometimes been used to avail of steam power
- A power operated winch is used to raise and lower and the rods.
- The walking beam is operated by a crank through gearing from an engine to give the drilling tool 25 to 30 blows per minute and a stroke of nearly 225 mm.
- The rods are attached to the rope with a swivel attachment and bracehead.
- Water is forced down the hole of the hollow drill rods by a pump to keep the cutting tool cool.
- Such water returns to the surface from the outside of the rods with the sludge
- Water flushing eliminates the use of sludger.

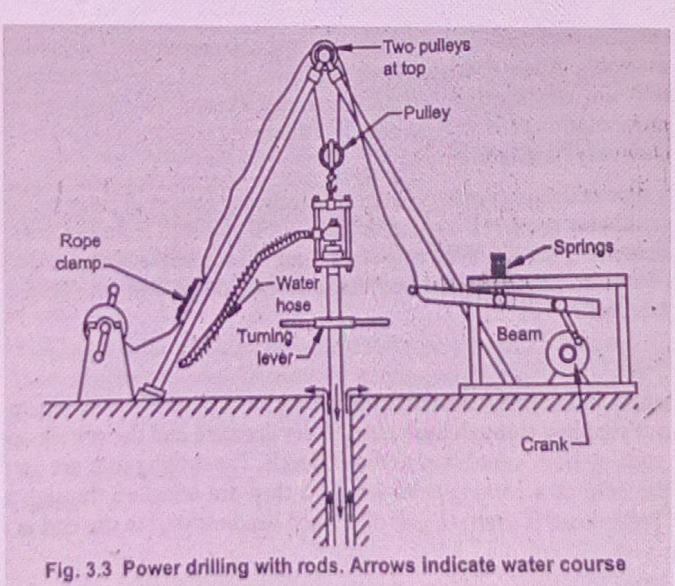

Fig. 3.3 Power drilling with rods. Arrows indicate water course

Rope drilling or cable drilling

- Where the percussive method of drilling is employed cable drilling is commonly adopted for holes deeper than 30 m.
- In this system the rigid rods are replaced by a steel wire rope to which the drilling tool is attached.
- The surface arrangement is practically the same as for drilling with rods, but the end of the walking beam is attached to a temper screw
- The rope from a winch is taken to the clamps of the temper screw across the pulley of the derrick

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- The surface arrangement is practically the same as for drilling with rods, but the end of the walking beam is attached to a temper screw
- The rope from a winch is taken to the clamps of the temper screw across the pulley of the derrick
- Feed of upto 1.2 m is possible with the use of the temper screw.
- When no more feed is possible the temper screw is run back and the rope reclamped 1.2 m higher up.
- During rope drilling no device is necessary to give a twist to the drilling tool between successive blows as the lay of the stranded rope causes the tool to twist slightly.
- The steel rope may be 18 mm diameter for a depth of 300 metres. The ropes have always a left-hand lay, so that the spin of the rope which tends to rotate the drilling tool also tends to tighten the joints between them.
- Cable drilling is also known as churn drilling

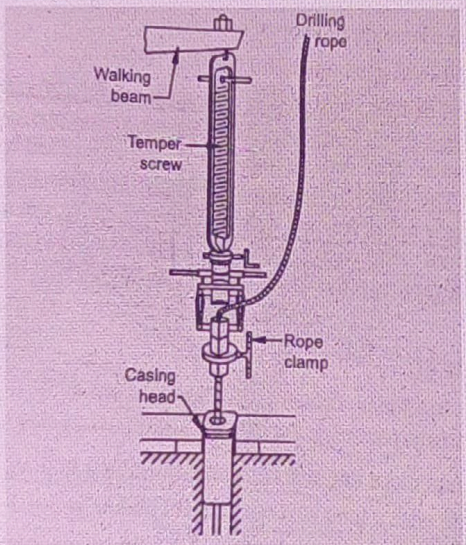
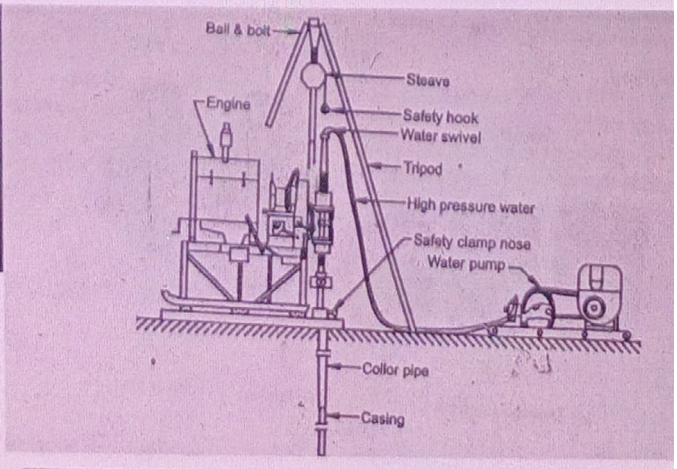


Fig. 3.4 Rope attachement in churn drilling

Rotary

- For rotary drilling, hollow drill rods of steel or aluminium are used.
- These are thread connected and transmit torque and feed pressure to the drilling bit which is attached at the end of a column of the drill rods.
- Rotation of the drill rods is through gearing driven by a prime mover at the surface.
- As the rods rotate, the drilling tool abrades the rock and the cuttings are cleared by pumping water under pressure or compressed air down the hole through the hollow drill rods.
- In some drillings, specially those for oil exploration, mud which is not very viscous, is circulated instead of water. The mud which keeps back any water, gas or oil pressure encountered during drilling is known as bentonite, aquagel, etc.
- Bentonite or aquagel fills the fractured or friable zone
- The couplings, which are the parts most exposed to wear, are made of chromium-nickel steel.
- Aluminium rods offer numerous advantages, such as increased machine capacity, easier handling, more rapid and simple recovery of the drill string and faster rotation, all of which contribution to simplifying drilling and reducing costs.
- The various methods of rotary drilling are known by the type of drilling tool used but the diamond drilling method is quite common.



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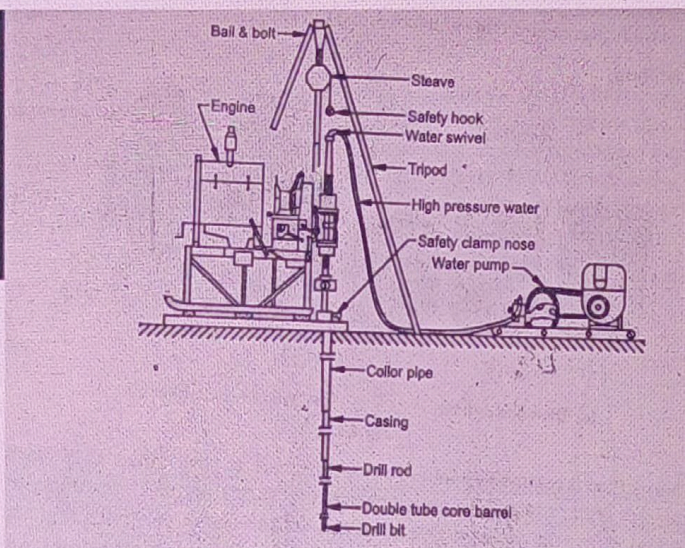

Fig. 3.6 Surface Arrangement for Rotary Drilling

Diamond drilling

- This method is commonly adopted where cores of rocks are desired for accurate records of the strata or for testing the rocks for their strength, composition, porosity, etc.
- Drill bit consists of a cylindrical cast steel shell having in its lower face a number of small sockets in which pieces of black diamonds are set.
- These diamonds are not useful as jewellery but are used in the drill bits for their hardness and the bit is suitable for the hardest rocks.
- The hole sizes in diamond drilling are designated as NX, BX, AX, and EX.
- The drill rods and the drill bits are specified under two main groups, X series and W series, as per the standards laid down by DCDMA (Diamond Core Drill Manufacturer's Association), an international Association.
- The drill hole diameters and core sizes (in mm) available are given below.

Standard	Drill rod outside dia.		Hole dia. mm	Core dia. mm.
	X series in inches	W series in mm.		
NX....	2.3/8	NW – 67	75	54
BX	1.29/32	BW – 54	60	40
AX	1.5/8	AW – 44	47	28

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BX	1.29/32	BW – 54	60	40
AX	1.5/8	AW – 44	47	28
EX....	1.5/16	EW – 35	38	21

Surface arrangements for diamond drilling

- a derrick
- an engine for supplying power
- an winch
- pump for supplying water under pressure for flushing
- a setting tank
- a platform for keeping the drilling rods lifted for removal of core or changing the bit
- core boxes for keeping the cores
- a driving and feed mechanism for the drill rods.
- The diamond drill bit is rotated at a speed of nearly 300 r.p.m. and the pressure on the diamonds is between 1.5 and 2 kgf/cm².
- The pressure acting upon the diamonds of the drill bit and the rate of advance of the drill bit into the rock are controlled by an arrangement known as "feed mechanism.
- The feed mechanism is hydraulic for deep holes and screw feed for shallow holes.
- Beyond a depth of nearly 60 m. the weight of the rods keeps the bit pressed against the rocks and the feed mechanism may not be necessary.
- At greater depth the feed mechanism is operated in such a way that the weight on the drill bit is not excessive.

Core recovery

- To collect the core of the rock drilled, a device known as the core barrel is used.
- It's length varies from 0.5 to 3 m.
- There are two types of this:-
  - The single tube core barrel
  - Double tube core barrel
- A single tube core barrel is suitable for homogeneous formations where the core is not eroded by flushing water and a solid core can be taken without risk of blockage in the barrel.
- The diamond crown or single tube core barrel is also called calyx

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- The core lifter is placed within the bevel shell which has its inside conically shaped to receive the former.
- The core lifter has a split ring.
- It occupies the wider portion of the bevel shell when drilling takes place so that it has little or no tendency to grip the core.
- After certain progress in drilling when the rods are lifted to take out the core, the split ring descends inside the bevel shell and grips the core.
- The latter may now be broken off by a twist and raised to the surface.
- The core is replaced after about 250m of drilling.
- The larger particles of drill cuttings which the circulating water fails to carry upto the surface settle down in the mud bucket. Where supply of flushing water is plentiful. The water under circulation is nearly 900 litres per minute.

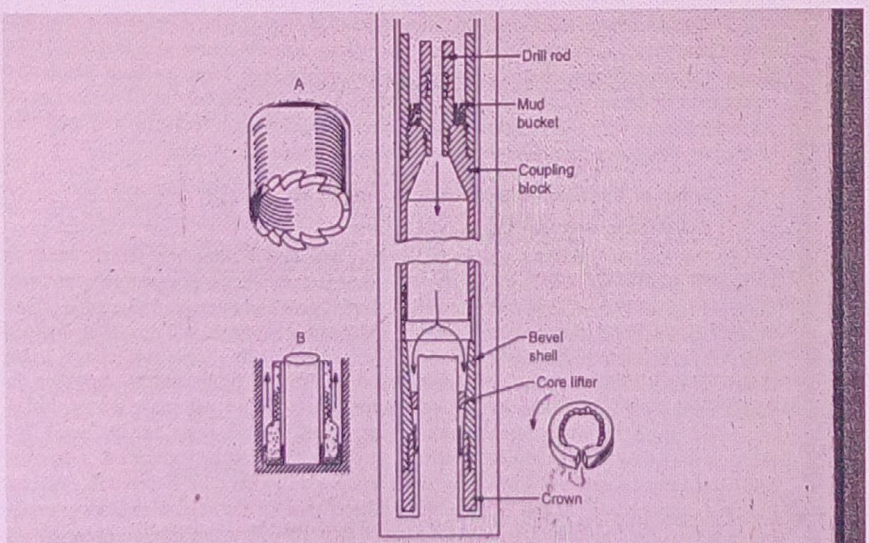

Fig. 3.10 (Left) A – Saw-toothed crown ; B – Chilled, shots during drilling (Middle) Single - tube core barrel

- In soft and friable rocks, the core is partially washed away due to the circulating water flowing past it.
- The rotation of the barrel greatly assists in grinding the core so that its recovery in a single tube core barrel is poor.
- To avoid these difficulties a double tube core barrel is used, specially where good core of soft rock is desired.
- In a double tube core barrel the inner tube which holds the core does not rotate during drilling.
- A double tube core barrel improves drill bit economy and overall drilling performance.
- Core recovery is good in hard uniform rocks, but poor in loose, soft, friable or weathered rocks.
- Vibrations of drill rods result in poor recovery.
- In hard rocks, to achieve good core recovery the drill should be run at low speed and heavy pressure
- In soft rocks, reverse procedure should be adopted.
- The combination of pressure on drill bit and its rotational speed should be such as to give vibration-free drill string during drilling.

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Wire Line Drilling

- Normally core barrels of 0.5 m to 3 m length are employed.
- For removal of core during the conventional method of drilling, all the drill rods have to be withdrawn to the surface, after firing a length equal to length of core barrel.
- The withdrawal of the rods and their re-introduction into the borehole with the additional drill rod, after removal of core, takes a considerable time, nearly 75 to 90% of the total time spent on drilling.
- A wire line drilling technique is an improvement to reduce this time.
- The rods are not taken out to remove the core which is collected in the core barrel tube during drilling.
- The tube is pulled out the surface through the drill rods with the help of a catcher which is lowered through the rods by a 5 mm dia, wire rope.
- The catcher grips the tube containing the core.
- Core size less than BX is not possible with wire line coring equipment
- The speed of drilling with this equipment is nearly 18 m per shift (8 hours) in the types of rocks met with in the coalfields.
- All the drill rods need to be withdrawn to the surface only when the bit has to be changed.
- Wire line drilling is possible upto a depth of 100m

Water Loss During Drilling

- When drilling in fractured zone or strata with cavities the circulating water is lost in such zone and fails to appear at the surface. This is known as water loss.
- To seal up the cavities or fractures around the hole, saw dust, husk, etc. are mixed in circulating water.
- If this is ineffective, it may be necessary to ream the bore hole and fix a casing pipe to cover the fractured zone.
- The casing pipe can be removed after completion of drilling.
- At depth, instead of resorting to a casing pipe a special type of mud like bentonite or kaolinite may be used to overcome the water loss
- Drilling mud is a suspension mixture of certain types of colloidal clay in water and/or oil and used as drilling mud.
- The mud most commonly used in diamond drilling is a slurry of clay and water.
- Properly controlled drilling mud slurries can prevent caving or collapse of borehole sides by building thin, impermeable protective coatings of clay particles to the walls of the hole.
- Diamond drilling method is suitable for drilling at any angle to obtain cores of friable Strata as well as the hardest rock
- It has been adopted for drilling upto a depth of 3000 m and hole diameter upto 200 mm. Drilling upto such large depths is not required in coal mining areas where the maximum drilling depth is upto 1000 m, as coal mines are rarely deeper than that
- Other methods of rotary drilling differ from the diamond drilling method essentially in the type of drilling bit used. The drill bits used are as follows
- The saw-toothed crown
  - The drilling tool is a saw-toothed steel crown or cutter. The teeth are set alternately inward and outward to give the necessary clearance. The speed of rotation is only 5 to 10 r.p.m. and the drill bits are suitable only for drilling through rocks of medium hardness; only holes of diameter not less than 150 mm are possible

- Rock roller bits
  - These are suitable for hole diameter between 75 mm and 300 mm. In mining areas these are commonly used for drilling large diameter holes in mechanised quarries.
  - Flushing of the hole with compressed air instead of by water under pressure is the common practice with this type of bit.
  - Rock roller bits can be used for deep hole drilling with speed and are suitable for mostly vertical downward holes.
- Chilled steel shots
  - These shots are prepared by heating very finely divided steel particles to a very high temperature and then suddenly cooling them in ice cold water
  - Chilled shots are used in with a plain steel shell or cylinder with a diagonal slot near the bottom.
  - They are fed through the hollow drill rods and pass to the bottom of the hole where they get caught between the bottom end of the cutting shell and the rock.
  - As the shell and the drill rods rotate, the chilled steel shots cut the rock by a milling action.
  - The method is suitable for vertical and large diameter holes of 100 mm to 750 mm.
  - It is also called calyx drilling, but is not much favoured these days as diamond drill bits have gained wide popularity and are available in large diameters upto 250 mm.
  - Calyx drilling proved to be a significant step during the development of drilling techniques.
  - Except the rock roller bits, all the other drilling tools used for rotary drilling provide cores of the strata passed through.

Borehole Deviation

- Borehole gets deviated from its original path, horizontally or vertically inclined
- Deviation is approx 2° per 30m length
- Deviation occurs at some angle
- Measurement of borehole deviation is called borehole

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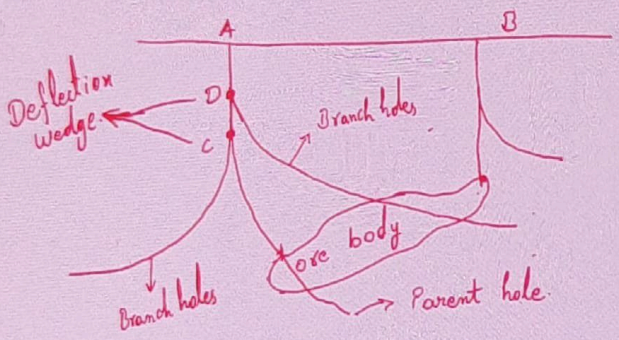
Borehole Deviation

- Borehole gets deviated from its original path, horizontally or vertically inclined
- Deviation is approx 2° per 30m length
- Deviation occurs at some angle
- Measurement of borehole deviation is called borehole survey
- Borehole deflection
  - Done by driller to control deviation
  - Intentional deviation



Major factors affecting borehole deviation

- Depth
- Angle
- Nature of strata drilled

Rules of borehole deviation

- Upto 100m depth deviation is small
- Deviation increases with depth
- Boreholes follow the bending planes
- Bending planes are found between hard and soft rock and in dykes and faults

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- Bending planes are found between hard and soft rock and in dykes and faults

Borehole deviation depends on

- Hole dia
- Bit pressure
- Core barrel
- Casing
- We can control borehole deviation with these practices

Dia of hole

- Large dia – less deviation
- Small dia – more deviation
- BX size – deviation is 2° to 3° per 30m depth
- AX size – deviation gets doubled
- EX size – deviation gets tripled

Bit pressure

- High bit pressure increases deviation
- Sharp bit with less bit pressure results in less deviation

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Bit pressure

- High bit pressure increases deviation
- Sharp bit with less bit pressure results in less deviation

Core barrel

- Diamond drill hole remains straight
- Hole does not deviate due to barrels but it depends on:-
  - Stiffness of barrel
  - Clearance in hole

Borehole survey

- Measurement of deviation
- Objectives of borehole survey
  - Direction of borehole
  - To find out points of deviation
  - With this 3D information at different angles can be determined

Methods of borehole survey

- Etch method – Hydroflouric acid is used
  - Measure deviation in angle only
  - HF acid corrodes glass

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Borhole deflection methods

- Casing deflection
- Use of wedges
- Sonic orienting assembly
- Arc cutting

Directional drilling

- To control direction of borehole
- To follow a pre determined path
- To complete borehole at desired point

8:42 0.03 KB/s 5G+ 66

Types of mineral reserves

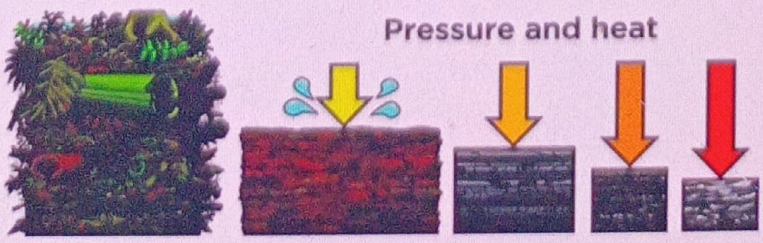
- Indicated Mineral Resource- Indicated mineral resources are those for which quantity, grade (or quality), densities, shape, and physical characteristics are estimated with sufficient confidence to allow for detailed planning and evaluation of economic viability. The information on these mineral resources is derived from exploration activities such as drilling, sampling, and geological modelling. Although the data is considered reliable, there may still be some uncertainties, albeit less than with inferred resources.
- Proved Mineral Reserve- Proved mineral reserves are the highest level of confidence in mineral resources. These are economically mineable portions of indicated mineral resources for which technical, economic, and environmental factors have been thoroughly assessed and demonstrated to be viable for extraction under current economic and operating conditions. Proved reserves are typically supported by detailed engineering studies, feasibility reports, and other comprehensive assessments.

Interpretation of geological maps

- Interpreting geological maps involves analyzing various features, symbols, and information presented on the map to understand the geological characteristics of an area. Here's a step-by-step guide to interpreting geological maps:
- **Legend**- Begin by reviewing the legend or key provided on the map. The legend explains the symbols, colors, and patterns used to represent different geological features such as rock formations, faults, folds, and mineral deposits. Familiarize yourself with the legend to understand what each symbol or color represents.
- **Rock Units and Formations**- Identify the different rock units and formations depicted on the map. These are typically represented by different colors or patterns and are labeled with names corresponding to geological formations. Pay attention to the age of each formation, which is often indicated on the map. Understanding the distribution and relationships between rock units can provide insights into the geological history and evolution of the area.
- **Geological Structures**- Look for symbols and markings that represent geological structures such as faults, folds, joints, and unconformities. These features are crucial for understanding the deformational history and structural geology of the area. Note the orientation, type, and relative age relationships of geological structures to infer past tectonic events and deformation processes.
- **Topography and Landforms**- Consider the topographic contours and landforms depicted on the map, as they influence geological processes and land surface features. Identify valleys, ridges, hills, and other landforms that may be associated with geological formations, erosion patterns, or structural features.

- **Geological History and Events**- Use the information provided on the map to reconstruct the geological history and events that have shaped the landscape over time. Look for evidence of sedimentation, erosion, volcanic activity, metamorphism, and other geological processes recorded in the rock formations and structures.
- **Geological Contacts and Boundaries**- Pay attention to contacts and boundaries between different rock units, as these represent transitions between geological formations or changes in lithology. Contacts may be sharp or gradational and may exhibit features such as unconformities or intrusive bodies.
- **Geological Features of Interest**- Identify any specific geological features of interest, such as mineral deposits, ore bodies, fossil locations, or geohazards (e.g., landslides, sinkholes) marked on the map. These features may have economic, environmental, or scientific significance and can be further investigated or studied.
- **Scale and Orientation**- Consider the scale and orientation of the map to understand the spatial extent and resolution of geological features depicted. Pay attention to north orientation and map scale to interpret distances and relationships accurately.
- **Cross-Referencing with Other Data**- Cross-reference the geological map with other geological data sources, such as field observations, drill logs, geophysical surveys, and remote sensing imagery, to validate interpretations and gain a comprehensive understanding of the geological setting.

COAL in INDIA



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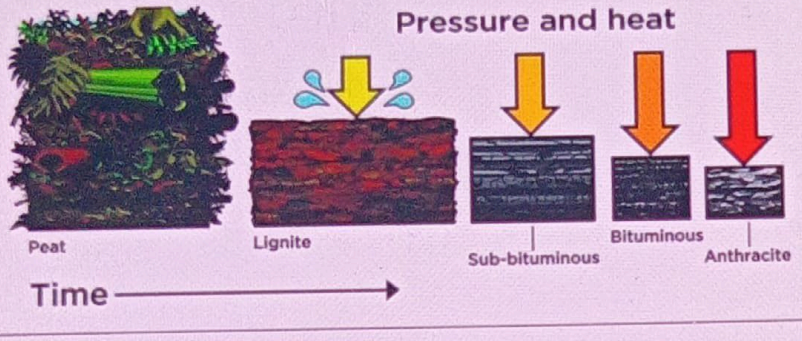
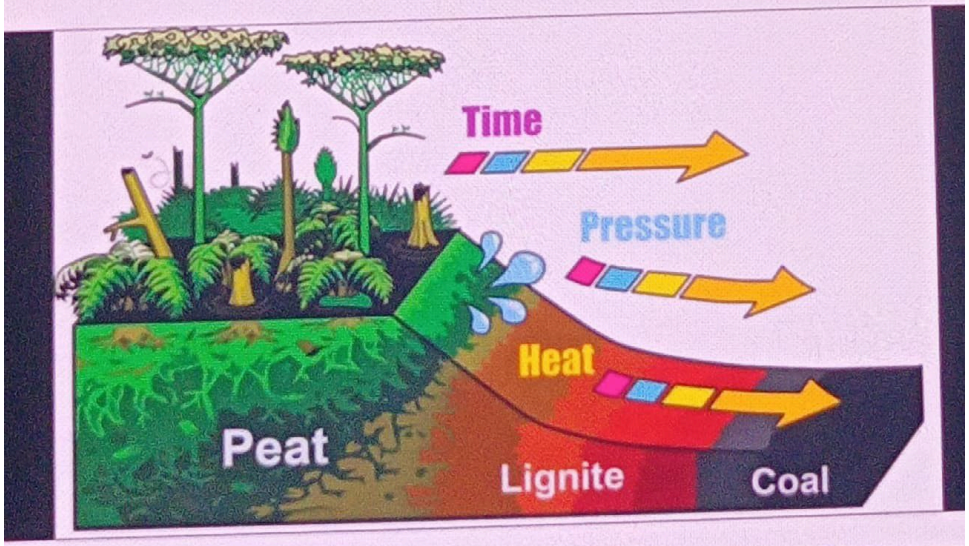
COAL in INDIA





Coal in India

- It is also known as Black gold
- Thermal power plant use 70% of total coal production
- It is a type of sedimentary rock basically found in layers
- It contains – Carbon, volatile matter, moisture, ash, sulphur, phosphorous
- We get good quality of coal from the Gondwana system which is of the Mesozoic Era
- Along with the time proportion of Oxygen, nitrogen and moisture decreases
- Along with the time carbon content remains same

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- Along with the time carbon content remains same
- Gases found in coal are – hydrogen, oxygen, nitrogen and sulphur and sometimes chlorine and sodium are also found

Types of coal on the basis of rank

- Peat
  - 40 – 50% carbon
  - More ash
  - More impurities
  - Light brown
- Lignite
  - Brown coal
  - 40 – 55% carbon
- Bituminous
  - Soft coal
  - 40 – 80% carbon
  - Black and compact
- Anthracite
  - Ignites slowly
  - Burns with low blue flame
  - Found in J&K

Origin of coal

- Coal is a combustible black or brownish-black sedimentary rock, formed as rock strata called coal seams.
- Coal is mostly carbon with variable amounts of other elements mainly hydrogen, sulphur, oxygen and nitrogen.
- Coal is formed when dead plant matter decays into peat and is converted into coal by the heat and pressure due to deep burrial of over millions of years
- Formation of coal seam
  - Insitu theory
  - Drift theory

Drift theory or Allochthonous theory

- According to this theory the plant debris is transported with the flowing water from one place to another and finally gets deposited in the place like swamps, lakes and seas.
- These places have suitable conditions of

8:43 131 KB/s 5G+ 66

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Insitu theory or Autochthonous theory

- According to this theory, the areas where the vegetation grew, subsided and the trees were submerged in water which flew into the subsided area.
- They were burried beneath the earth and sand brought by the water.
- Fresh vegetation grew over the debris in the area and this process repeated over thousands of years

Rank of coal

- Rank of coal indicates the carbon content of it
- The heating value of the coal depends on the percentage of hydrogen and carbon
- Anthracite – sp.gr. 1.47
- Bituminous – sp.gr. 1.32
- Sub bituminous – sp.gr. 1.30
- Lignite – sp.gr. 1.2
- The thickest coal seam in India is Jhingurda top seam (130 – 162m). It belongs to gondwana period

Gondwana period

- Gondwana coal makes upto 98% to the total reserves and 99% of the production of coal in India
- The carbon content in Gondwana coal (250million years old) is less compared to the Carboniferous coal (350million years old)
- The Damuda series (i.e. lower gondwana) possesses the best worked coalfields accounting for 80% of the total coal production in India.
- Coking coal as well as non coking coal and bituminous and sub bituminous coal are obtained from Gondwana coal fields
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- The volatile compounds and ash (usually 13 – 30%) and does not allow carbon percentage to rise above 55 – 60%
- Gondwana coal is free from moisture, but it contains Sulphur and Phosphorus

Distribution of Gondwana coal in India

- First coal mine was opened in 1774 at Raniganj in West Bengal
- Coal industry was nationalized in 1973 – 74.
- India is now the third larges coal producer in the world after China and the USA
- Coal industry provides employment to nearly 7lakh people
- Gondwana coalfields are exclusively found in Peninsular plateau of India

Gondwana coalfields in Chattisgarh

- Korba coalfield – Korba district
- Bisrampur, hasdeo, chirmiri, lakhanpur coalfields – Anuppur district
- Jhilmili coalfield – shahdol district
- Johilla coalfield – Johilla valley
- Sonhat, tatapani – ramkota coalfields – Sarguja district

Gondwana coalfields in Jharkhand

- 1st in reserves (28%)
- 2nd in production (20%)
- Oldest and richest coalfields of India
- Coking coal is mainly found over here
- Jayanti coalfields – coal is of inferior quality and high ash content
- Girdih coalfields – finest coking coal of India is found over here
- Huttar coalfields – coal is of low quality and used in cement and brick kiln
- Most of the coalfields are located in a narrow belt running in east

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- Most of the coalfields are located in a narrow belt running in east – west direction
- Major coalfields are present in Dumka, Hazaribagh, Dhanbad, Palamau
- Jharia, Bokaro, Girdih and Karanpura are the major coalfields

Gondwana coalfields in Odisha

- Talcher coalfields
  - Ranks second in reserves (24,374MT) after Raniganj
  - Coal is suitable for steam and gas production
  - Used by thermal power plants and fertilizer industries at talcher

Gondwana coalfields in MP

- Singrauli (waidhan) coalfields
  - Jhingurda, Panipahari, Khadia, Purewa and Turra are the Important coal seams of the area
  - It used in thermal power plants
- Pench, Kanhan and Tawa coalfields
  - Ghoravari seam in kanhan coalfields is 4.6m thick contains coking coal
- Umaria coalfields
  - Coal is of low quality
  - High percentage of ash and moisture

Gondwana coalfields in Andhra Pradesh

- 6th in reserves (7.07%)
- 5th in Production (9.69%)
- Most of the coal reserves are in godavari valley
- Workable collieries are situated at singareni and kothagundam

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- 6th in reserves (7.07%)
- 5th in Production (9.69%)
- Most of the coal reserves are in godavari valley
- Workable collieries are situated at singareni and kothagundam
- Coal is of non coking variety

Gondwana coalfields of Maharashtra

- 3% reserves of India
- 7% production
- Kamptee coalfields in Nagpur districts
- Wun coalfields in Yavatmal districts
- Wardha valley, Ghughus, Ballarpur and warora in chandrapur district

Gondwana coalfields in West Bengal

- 4% of Indias coal production
- 11% of coal reserves
- Darjeeling and jalpaiguri chief producing districts
- Raniganj is the largest coalfields of west bengal
- Non – coking steam coal is found here

Tertiary coal India

- Tertiary coal is 15 – 60 Million years old
- Carbon content is very low
- Mainly confined to the extra – peninsula (J&K, Himachal pradesh, Assam, Arunachal Pradesh)
- Coal generally has low carbon and high percentage of moisture and sulphur.
- Important areas of tertiary coal include parts of Assam, Meghalaya, Arunachal pradesh, Nagaland,

8:46

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Tertiary coalfields in Assam

- Makum, Nazira, Mikir hills, Dilli-jeypore and Lakhuni
- Makum coalfield in sibsagar district is the most developed field.
- Assam coal contain very low ash and high coking qualities but the sulphur content is high, as a result of which this coal is not suitable for metallurgical purposes
- But these coal are best suited for hydrogenation process and are used for making liquid fuels

Tertiary coalfields in Arunachal Pradesh

- Upper Assam coal belt extends eastwards as Namchick-Narup coalfield
- High in volatiles and in sulphur

Tertiary coalfields in J&K, Himachal Pradesh

- Kalakot and surrounding region in Jammu, south of Pitpanjal
- Himachal Pradesh – Chamba district

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Tertiary coalfields in J&K, Himachal Pradesh

- Kalakot and surrounding region in Jammu, south of Pitpanjal
- Himachal Pradesh – Chamba district

Tertiary coalfields in Meghalaya

- Garo, Khasi and Jaintia hills
- Darrangi field – Garo hills
- Siju, Cherrapunji, Liotryngew, Maolong and Langrin coalfields – Khasi and Jaintia hills

Lignite in Tamil Nadu

- 90% of the reserves
- 57% of the production
- Neyveli Lignite fields of cuddalore district
- These are the larges deposits of lignite in south – east asia
- Neyveli mines suffer from the artesian structure i.e. mining goes deep and deep
- Mining in lignite coalfields is risky due to spontaneous combustion of lignite

Difference between coking and non coking

COKING COAL	NON – COKING COAL
▪ High carbon content, less moisture, less sulphur, less ash ▪ Used to create coke. Coke is produced by heating	▪ Sulphur content is high and hence cannot be used in iron and steel industry ▪ Creating coke using this coal is not economical and traces

8:47 0.08 KB/s 5G+ 65

Difference between coking and non coking

COKING COAL

- High carbon content, less moisture, less sulphur, less ash
- Used to create coke. Coke is produced by heating bituminous coal without air to extremely high temperatures
- Coking means flushing out of impurities and improving the concentration of carbon
- It is an essential ingredient in steel production

NON – COKING COAL

- Sulphur content is high and hence cannot be used in iron and steel industry
- Creating coke using this coal is not economical and traces of sulphur will remain even after coking
- Thermal coal is used to generate power

Banded constituents of coal

- The bituminous coal contains 4 different visible bands
  - Vitrain
  - Clarain
  - Durain
  - Fusain
- These are the rock types not chemical entities
- But different vitrains have different chemical compositions
- Subdivisions of these rock types into macerals and petrological units are:-
  - Vitrinite
  - Fusinite
  - Exinite
  - Resinite
  - Micrinite

Banded constituents of coal

- All four bands are not present in the same sample of coal
- Generally only two bands exist
- Vitrain
  - It forms the bright layers
  - Glassy texture
  - It is found in high quality coal
  - It is friable
  - It breaks in small cubes and rectangular pieces
  - It is clean to touch

Continued...

- Clarain
  - It is also in bright layers
  - It is parallel to the bedding plane
  - It does not soil the fingers
  - It resembles vitrain
- Fusain
  - It has dull appearance
  - It is friable
  - Soils the fingers
  - It is the most impure band of coal

8:47 0.48 KB/s 5G+ 65

Continued...

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  - It is present in high quality coal
- Durain
  - It has dull appearance
  - It is lenticular in shape
  - It is hard
- Fusain
  - It has dull appearance
  - It is friable
  - Soils the fingers
  - It is the most impure band of coal
  - The layers resembles charcoal
  - It is present in all types of coal

Coal analysis and commercial grades

- Size gradation of coal
  - Steam coal – 50mm to 200mm
  - Rubble coal – 25mm to 50mm
  - Slack coal – 0mm to 25mm
- Run of mine (ROM) coal
  - It is the unscreened coal of all sizes

- Quality of coal depends on:-
  - The chemical composition of the original plant
  - The mode of accumulation and burial of the plant debris
  - Inorganic matter that got mixed in the plant material
  - Extent of decay
  - Age of deposits
  - Geological disturbances

Analysis of coal

ULTIMATE ANALYSIS

- It gives the percentage of elements present
- Like - O_2, N_2, carbon, H_2, sulphur, phosphorus
- It gives suitability of coal for chemical industry purposes

PROXIMATE ANALYSIS

- It gives percentage of ash, moisture, volatile matter and fixed carbon
- It gives the percentage by weight

Various constituents of coal

- Ash – it is the inorganic residue left when coal or coke is burned in air to get constant weight
- Moisture – it is the water expelled in various forms when coal is heated
- Volatile matter - Various gases in coal = total loss in weight – moisture when coal or coke is heated
- Fixed carbon = 100 – sum of percentage of moisture, ash and volatile matter
- Free moisture – the free or visible water present on the surface of or in cleavages and cracks
- Inherent moisture – the moisture present inside the coal

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- Inherent moisture – the moisture present inside the coal
- Total moisture – it is the sum of free moisture and inherent moisture

Coal reserves

- The quantity of coal available in a coal seam in-situ is called its reverses which are generally expressed upto a specified depth.
- Proved reserves
  - These are reserves estimated from dimensions of the coal seam revealed in outcrops, trenches, mine workings and boreholes by assuming their continuity of geological evidence for a distance upto 200 m from the point of observation.
  - A reserve is considered as proved reserve if it is probable that at least 90% of the resource is recoverable by economically profitable means
- Indicated reserves
  - These are determined by taking an area of 1000 m x 1000 m for each point of observation where coal seam is indicated. This may be extended to2000 m x 2000 m for known geological continuity.
- Inferred reserves
  - This is an estimate of coal based largely on broad knowledge of geological character of beds but for which there is at measurement.

9:11 | 21:31 0.48 KB/s 4G 62

Boring & Drilling

A study of the rocks exposed at the surface, their structures and the geology of the areas gives sufficient information of the conditions that may be available below ground. More detailed information is, however, obtained by boring and interpretation of the data available from it. The term *drilling* is nowadays coming into use for boring.

In mining an allied branches of engineering drill holes may be drilled for the following purposes.

1. To prove the existence of minerals, to get an idea of rock structures and to obtain knowledge of the rocks and the mineral beds, such as depth, nature, thickness and gradient.
2. To get core of the rocks from which gearing pressure of the ground can be found out. This information is necessary for heavy winding engine foundations required for deep shafts.
3. To know throw of the faults; this is conveniently done from underground workings.
4. To drain off gas or water from old workings.
5. To carry electric cables, signal wires, stowing pipes or water pipes to the underground from surface.
6. To have tube wells for water supply to colonies.
7. To blast rock/mineral in a mechanised quarry where holes of 9 to 18 m depth and 125 to 300 mm in dia. may be drilled.
8. To render possible the injection of cement into the strata in a method of shaft sinking known as "cementation method of shaft sinking".
9. For ventilation of underground mine workings.

Drilling Method

Detailed information is obtained by drilling & interpretation of the data available.

→ Drill holes may be drilled - to prove the existence of minerals, for ventilation of U/G mine workings.

* Drilling Method

- Percussive (impact action)
  - By rigid rods
  - Rope drilling / Cable drilling / Churn drilling
  - By saw toothed Cutters
- Rotary (Cutting & ploughing) drilling
  - By chilled shots
  - By tricone rock roller bit
  - By diamond drill bit

* Percussive drilling :-

9:11 | 22:05 43.1 KB/s 4G 61

Drilling Method

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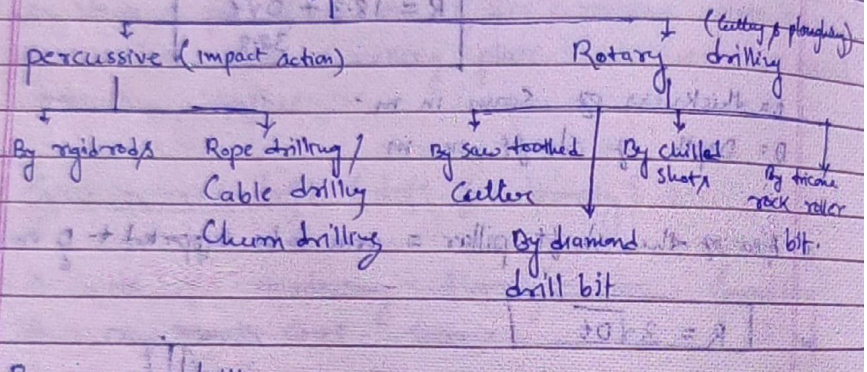
* Drilling Method -



* Percussive drilling :-

→ the hole is drilled by striking a no. at short intervals on the rock by a chiesel type tool & betn the blows the tool is rotated slightly.

→ the Chiesel is suspended from the surface by rod or Cable rope

→ rock is chipped away with each blow & a Circular hole is formed.

* Drilling with rods -

- the rods are Ni-Cr or Carbon steel
- Steel rods are 3m in length with nearly 32mm x 38mm square Cross sect
- for rotary drilling - the rods are hollow Circular in Cross section, have flush joints.
- Soft surface deposit → Auger (clay) and worm may be used. they gives rotary rather than percussive mot
- for hard Strata → Straight chiesel, V chiesel & T Chiesel

* Manual drilling :- Corking bush (rocking lever) is connected to the drill rods which gives a percussive mot to the drill rod

- During drilling the bottom of the hole soon gets filled with Cuttings & has to be Cleaned out frequently
- this is done with the help of Sludger - open at the top & with a flap valve at its lower end (Cylindrical)

* fishing the bore hole :- the operation of tracing the broken

the top & with a flap valve at its lower end (Cylindrical)

* Fishing the bore hole :- the operation of tracing the broken and lost parts of drill bits in the hole and withdrawing them to the surface is known as fishing the bore hole - Crows foot, and spiral grom

* Lining a drill hole :- for lining a steel pipe is used from surface upto the hard rock.
- the drilling tools and rods pass through the pipes
- lining is done to prevent caving of sides.

* power drilling with Rods :-
- manual drill is suitable for holes upto 150mm ϕ upto a depth of 30m.
- beyond 30m depth power drilling is used.
- power operated winch is used to raise & lower the rods
- water is forced down the hole of the hollow drill rods by a pump to keep the cutting tool cool

* Rope or Cable drilling :- (churn drilling)
- for percussive drilling, Cable drilling is adopted for holes deeper than 30m.
- Rigid rod is replaced by a steel wire rope to which drilling tool is attached.
- the end of the walking beam is attached to the tempor screw.

* Rotary drilling :- Hollow drill rods of steel or alloy are used.
- rods are thread connected & transmit torque & feed pressure to the drilling bit
- the drilling tools abrades the rock as the rods rotate
- Cuttings are cleared by pumping water under pressure or Compressed air down the hole through the hollow drill rods.
- water or air along with the cuttings are then to the surface through the space between the drill rod & the sides of the drill hole

* Diamond Drilling :-
- Adopted where Cores of rocks are desired for accurate records of the strata or for testing the rock for their strength, Composition, porosity ...

9:13 | 23:24 150 KB/s Vo LTE 4G 61

Diamond Drilling :-

- Adopted where Cores of rocks are desired for accurate records of the strata or for testing the rock for their strength, Composition, porosity etc
- Suitable for the hardest rock
- the hole sizes in diamond drilling are designated as NX, BX, AX & EX.
- The drill rods & the drill bits are specified under two main groups - X series and W series.
- there are Q series standards for coreline drilling rods
- standards of drill hole diameter with their Core sizes are given below :-

standard	Drill rod outside dia	Hole dia	Core dia
NX/NW	67	75	54
BX/BW	54	60	40
AX/AW	44	47	28
EX/EW	35	38	21

- The Core sizes where wire line drilling technique is adopted are:
NX holes → 44 mm, BX holes → 25 mm.

- Core recovery :- To Collect Core of the rock drilled a device known as Core barrel is used.
- Two types
i) Single tube Core barrel ii) Double tube Core barrel

- Single tube is suitable for homogeneous formation the Core is not eroded by flowing water.
- when the rods are lifted to take out the Core, the split ring descends inside the bevel shell and grips the Core.
- In Soft and friable rocks the Core is partially washed away due to the Circulating water flowing past it.
- the rotation of barrel grinding the Core so that the recovery in a single tube Core barrel is poor.
- To avoid these difficulties a double tube Core barrel is used.

* Method of Exploration Drilling :-

Types of drill	Size of hole	depth	Application
i) percussive	50-75 mm	300 m	Soft & med^m hard rock

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is cored.

* Method of Exploration Drilling :-

Types of drill	Size of hole	depth	Application
i) percussive with rod	50-75 mm	30 m	Soft & medm hard rock
ii) Churn drilling	75-500 mm	300-600 m	placer deposit, moderately soft formation
iii) Diamond drilling	30-200 mm	150-3000 m	Any rock formation or fissured
iv) Calyx or Chilled Shot drilling	75-1800 mm	< 45 m	Any rock drilling except hard

* Bore hole Survey :- Measurement of a drill hole deviation is called bore hole Survey.
- measure both angle and bearing deviation.

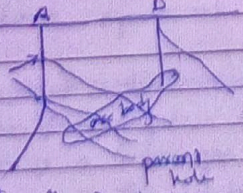
i) Etch method testing HF acid :- Used to measure deviation in angle only.
- HF acid has the property of corroding glass.
- when the tube is vertical the etch line will be normal to the axes of tube.
- In any other tilted position the etch line will make corresponding angle, this angle is known as etch angle.

ii) Bore hole Camera :- Continuous record of borehole deviation from top to bottom.

iii) Tropori method :- An instrument gives R.I of any pt along the hole.

* Bore Hole deviation :- The departure of a bore hole, whether vertical or inclined on its own is known as deviation of the bore hole.

* Deflection of a borehole is the deliberate & intentional deviation of a borehole brought about by the driller to Correct the borehole's Course Caused by deviation.



Deflect" eliminates the need for a no. of holes from the surface during prospecting.

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- Bore hole Camera :- Continuous record of borehole deviation from top to bottom.

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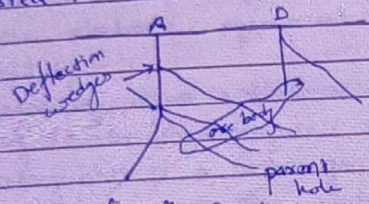

Deflect" eliminates the need for a no. of holes from the surface during prospecting.

- one parent hole at A Covers a wide area for prospecting with the help of deflected branch holes.

→ Deviation $\propto \frac{1}{\text{hole's dia}}$ $\propto$ high bit pressure

* Directional Drilling :- Directional drilling means Controlling the Course of a borehole so as to follow a predetermined path.

→ To Control deviation in a drill hole

→ UG gasification requires atleast two boreholes drilled from surface and Connected together in Coal Seam.
→ Air or some other reactant is pumped down one hole to Create Combustion and gas is removed from other.

Diamond drilling - Rotary, abrassive
percussive drilling - impact action
Rotary roller drilling - Cutting & ploughing
Jet piercing - Thermal spalling.

Sometimes a rod or chisel breaks in the drill hole during drilling. Devices like the crow's-foot and the spiral worm (Fig. 3.2) may be used to catch the broken rod under a joint in the borehole. Broken pieces of chisel are sometimes raised with the help of powerful magnets. In diamonds drilling, described later, the diamonds sometimes become loose and fall in the hole. The operation of tracing the broken and lost parts in the hole and withdrawing them to the surface is known as *fishing the borehole.*

Lining a drill hole : During drilling a steel pipe is used for lining the drill hole from surface upto the hard rock, and the drilling tool and rods pass through the pipe. Obviously, the length of the drill-hole upto which the lining pipe has to be fitted should be of a larger diameter. The lining pipe is generally withdrawn after the hole is completed though it may sometimes be necessary to leave it in its position to prevent caving of sides, *e.g.* drill hole for stowing, water pipes, etc.

The lining is done by hammering first a special steel pipe with a cutting edge. Pipes of 6 m lengths and having screwed joints are added to that pipe.

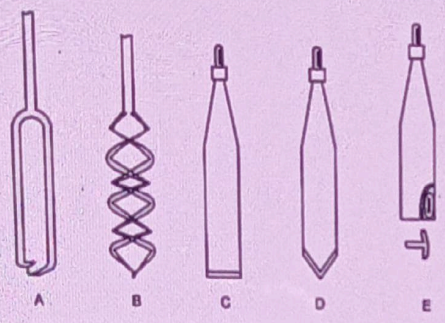

Fig. 3.1 Common types of drilling chisels and augers.
(A) Clay auger (B) Worm auger (C) Straight chisel (D) V-chisel (E) T-chisel

Power Drilling With Rods

Drilling with manual labour without the help of power is suitable for holes upto 150 mm in diameter and upto a depth of 30 m or so. Beyond that depth, it is impossible to drill without the use of power from a diesel or petrol engine, the common source of power in isolated drilling sites. Vertical boilers have sometimes been used to avail of steam power, specially where drilling had to be done in a colliery area where coal is easily available.

Fig. 3.3 shows the general arrangement where power is available for drilling with hollow rods. A power operated winch is used to raise and lower and the rods. The walking beam is operated by a crank through gearing from an engine to give the drilling tool 25 to 30 blows per minute and a stroke of nearly 225 mm. The beam is mounted on steel springs which give elasticity and cause sudden recoil of the frilling bit thereby preventing jamming. The rods are attached to the rope with a swivel attachment and bracehead. The rope of power-operated beam is slackened from time to time to keep the drilling tool in contact with the rock. Water is forced down the hole of the hollow drill rods by a pump to keep the cutting tool cool. Such water returns to the surface from the outside of the rods with the sludge. With this arrangement it is possible to drill a depth equal to the length of one full rod at a time. Water flushing practically eliminates the use of a sludger.

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Water flushing practically eliminates the use of a sludger.

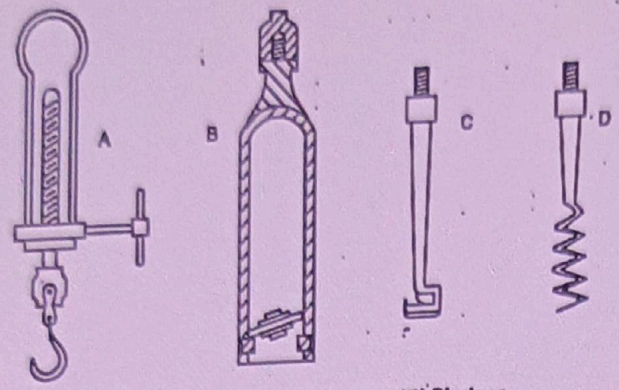


Fig. 3.2. (A) Stirrup and screw. (B) Sludger
(C) Crow's foot (D) Sprial worm

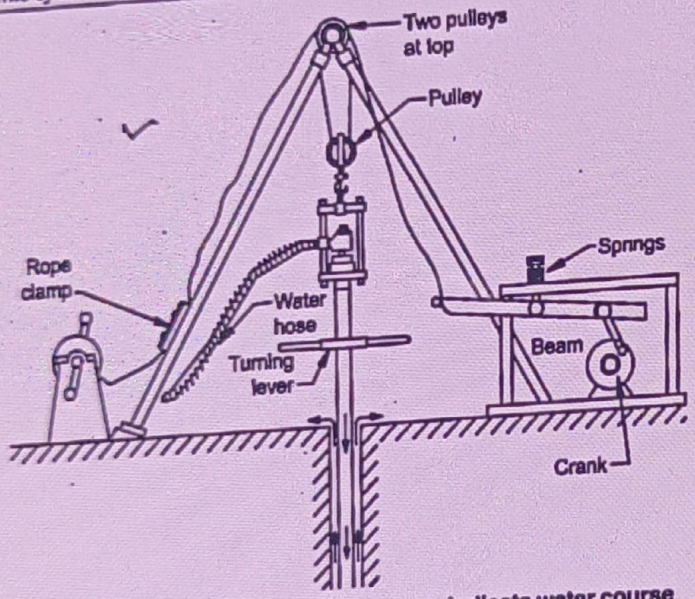


Fig. 3.3 Power drilling with rods. Arrows indicate water course

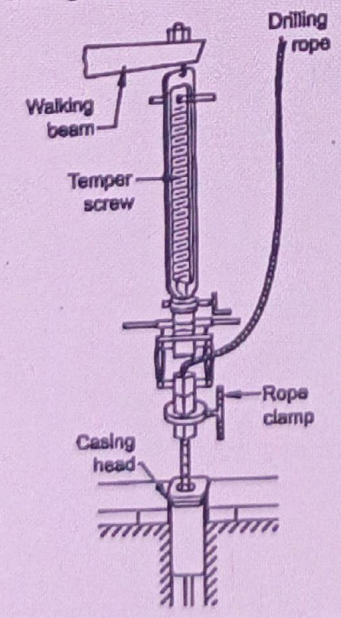


Fig. 3.4 Rope attachement in churn drilling

Where supply of flushing water is plentiful, calyx is not necessary. The water under circulation is nearly 900 litres per minute.

In soft and friable rocks, the core is partially washed away due to the

Where supply of flushing water is plentiful, calyx is not necessary. The water under circulation is nearly 900 litres per minute.

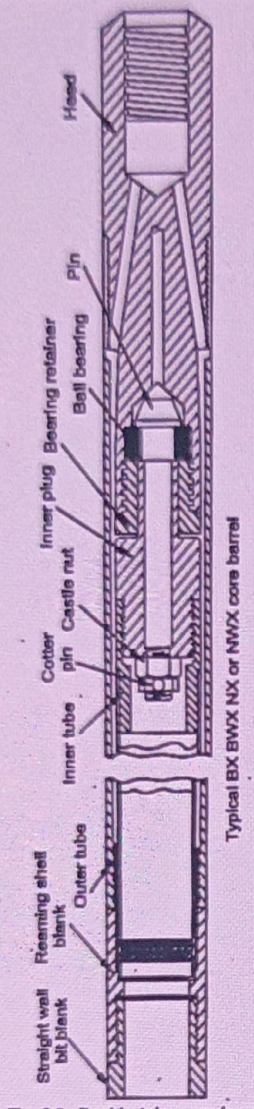
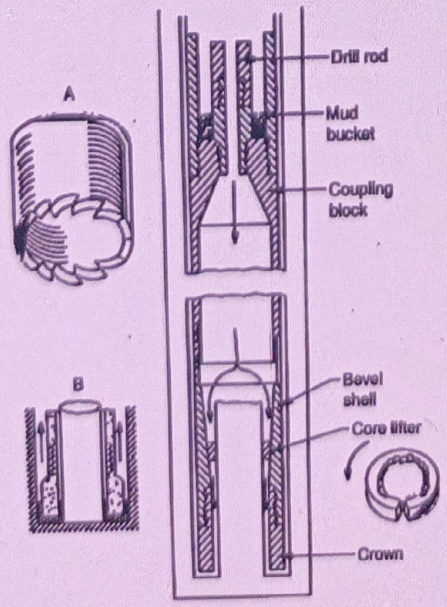


Fig. 3.9 Double tube core barrel

In soft and friable rocks, the core is partially washed away due to the circulating water flowing past it. The rotation of the barrel greatly assists in grinding the core so that its recovery in a single tube core barrel is poor. To avoid these difficulties a double tube core barrel is used, specially where good core of soft rock is desired. In a double tube core barrel in inner tube with holds the core does not rotate during drilling as it is suspended on ball bearings mounted in the block at the top of the barrel permitting the inner core barrel to remain stationary. Moreover, water does not flow past the core but in the annual space between the inner tube and the outer barrel and through channels near the bottom of the hole. A double tube core barrel improves drill bit economy and overall drilling performance. Core revoery is good in hard uniform rocks, but poor in loose, soft, friable or weathered rocks. Vibrations of drill rods result in poor recovery. In hard rocks, to achieve good core recovery the drill should be run at low speed and heavy pressure; in soft rocks, reverse procedure should be adopted. The combination of pressure on drill bit and its rotational speed should be such as to give vibration-free drill string during drilling.

It is also called calyx drilling, but is not much favoured these days as diamond drill bits have gained wide popularity and are available in large diameters upto 250 mm.



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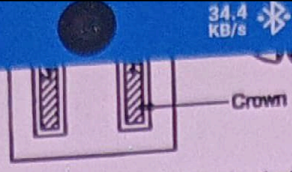

Fig. 3.10 (Left) A – Saw-toothed crown ; B – Chilled, shots during drilling (Middle) Single - tube core barrel

Calyx drilling proved to be a significant step during the development of drilling techniques.

Except the rock roller bits, all the other drilling tools used for rotary drilling provide cores of the strata passed through.

Underground Drilling

To drill a hole from underground workings for purposes of prospecting, stowing, tapping water or gas or any other object, the drill equipment has necessarily to be of smaller dimensions. This restricts the size and weight of the machine and therefore puts limitations on

3.2 Folds:

The wavy undulations in the rock beds are called "folds". They consist of arches and troughs in alternate manner. The size of folds varies greatly. Width of some folds are measured in kilometers while those of others in meters or centimeters. The details of the fold's terminology are shown in Figure 3-2.

3.2.1 TERMINOLOGY:

- ***Anticline***: It is on up fold where the limbs dip away from the axis.
- ***Syncline:*** It is a down fold where the limbs dip towards the axis.
- ***Limb:*** The sloping side of a fold from crest to trough is called the "limb".
- ***Axial Plane:*** It is an imaginary plane or surface which divides the fold into two equal halves.
- ***Axis:*** The line of intersection of the axial plane with the surface of any of the constituent rock beds is known as the "axis" of the fold.

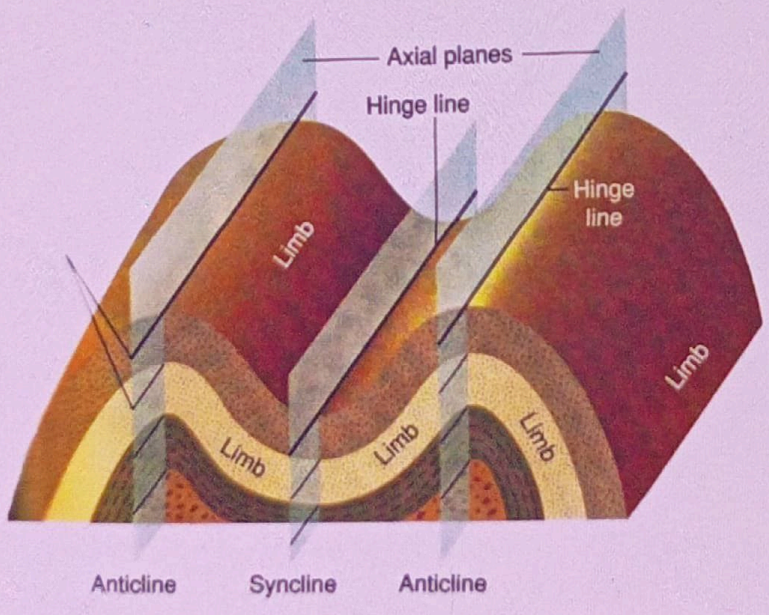

FIGURE 3-2: FOLDS

3.2.2 Types of Fold:

- **Symmetrical Fold:** A" Symmetrical fold" is one where the axial plane is vertical and the two limbs have the same amount of dip Figure 3-3.

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3.2.2 Types of Fold:

- **Symmetrical Fold:** A" Symmetrical fold" is one where the axial plane is vertical and the two limbs have the same amount of dip Figure **3-3**.
- **Asymmetrical Fold:** An "asymmetrical fold" is one where the axial plane is inclined and the limbs dip at different angles, and in opposite directions.
- **Overturned Fold:** "Overturned fold" is one in which the axial plane is inclined and one limb is turned past the vertical. In this case both the limbs dip in the same direction and one of the limbs is turned upside down.
- **Recumbent Fold:** In "recumbent folds" the folding is so intense that axial plane becomes almost horizontal and the lower limb, which also becomes nearly flat, gets overturned.

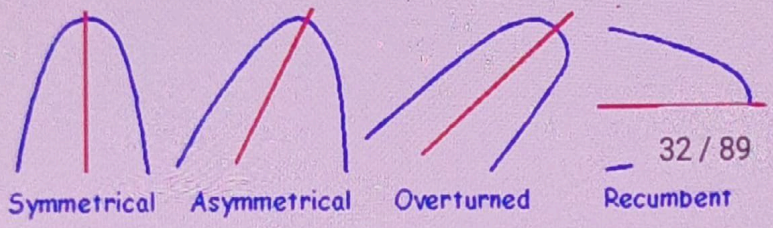

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FIGURE 3-3: SOME TYPES OF FOLDS.

In such folds, fractures may develop across bends and thrusting of the recumbent rock mass may take place, please see Figure **3-4**.

- **Isoclinal Fold:** This type of fold shows parallel limbs which dip at the same angle and in the same direction.
- **Dome and Basin:** When the strata have been subjected to folding in two directions at right angles, each anticline is converted into a "dome", and each syncline is converted into a "basin". In domes the beds dip away from a central point. In basins, the beds dip downwards a central point.

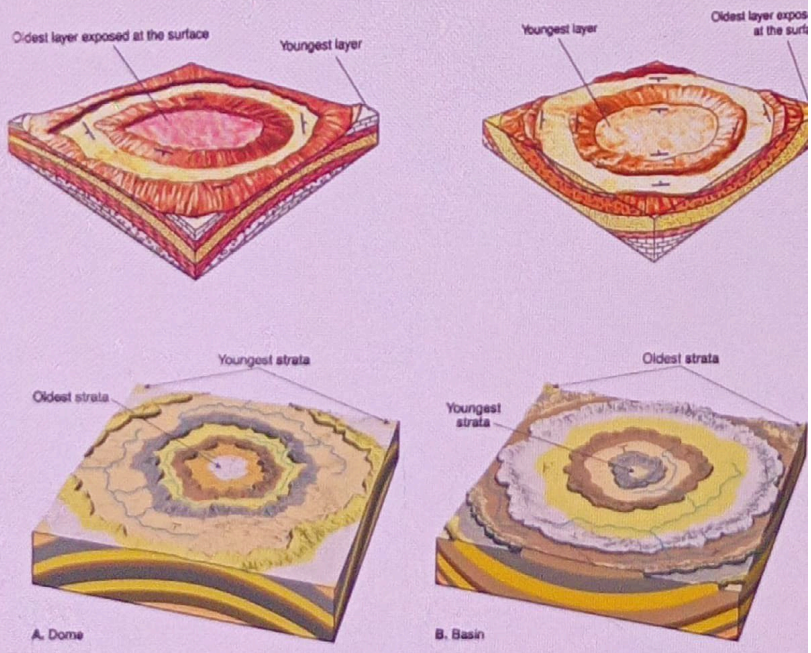

FIGURE 3-4: DOME AND BASIN FOLDS

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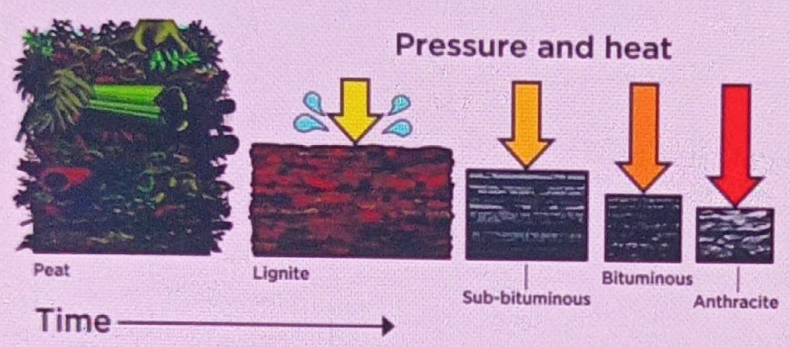
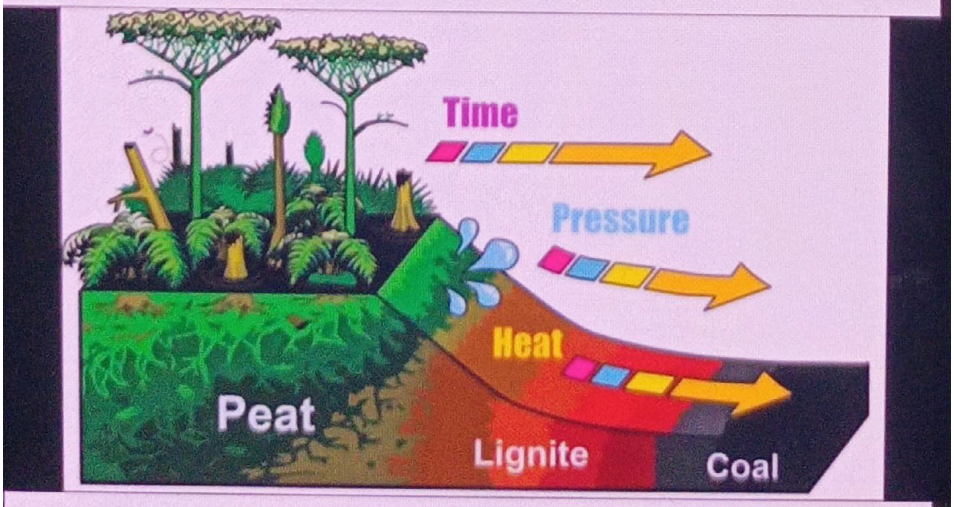
CHAPTER – 2
COAL AND COALFIELDS IN INDIA

Volume - 1

COAL in INDIA





Coal in India

Coal in India

- It is also known as Black gold
- Thermal power plant use 70% of total coal production
- It is a type of sedimentary rock basically found in layers
- It contains – Carbon, volatile matter, moisture, ash, sulphur, phosphorous
- We get good quality of coal from the Gondwana system which is of the Mesozoic Era
- Along with the time proportion of Oxygen, nitrogen and moisture decreases
- Along with the time carbon content remains same
- Gases found in coal are – hydrogen, oxygen, nitrogen and sulphur and sometimes chlorine and sodium are also found

Types of coal on the basis of rank

- Peat
  - 40 – 50% carbon
  - More ash
  - More impurities
  - Light brown
- Lignite
  - Brown coal
  - 40 – 55% carbon
- Bituminous
  - Soft coal
  - 40 – 80% carbon
  - Black and compact
- Anthracite
  - Ignites slowly
  - Burns with low blue flame
  - Found in J&K

Sources of energy

- There are various types of sources of energy available for the human consumption
- They can be renewable or non renewable sources of energy
- In India half of the actual energy consumption is of coal, oil, nuclear and hydel.
- The other half is non commercial like firewood, agriculture waste and animal excreta
- The share of coal is about 60% of commercial energy sources
- Wind power a source of non conventional renewable energy gives very little contribution in India.

Types of fuel

- Solid – Coke, coal, wood, charcoal, bagasse, lignite, cowdung etc.
- Liquid – diesel, petroleum and its derivaties, coal tar and its derivatives, shale oils, alcohol etc.
- Gaseous – lighting gas, coke oven gas, producer gas, blast furnance gas, water gas, natural gas etc.

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Types of fuel

- Solid – Coke, coal, wood, charcoal, bagasse, lignite, cowdung etc.
- Liquid – diesel, petroleum and its derivaties, coal tar and its derivatives, shale oils, alcohol etc.
- Gaseous – lighting gas, coke oven gas, producer gas, blast furnance gas, water gas, natural gas etc.
- Nuclear – Uranium based energy etc.

Origin of coal

- Coal is a combustible black or brownish-black sedimentary rock, formed as rock strata called coal seams.
- Coal is mostly carbon with variable amounts of other elements mainly hydrogen, sulphur, oxygen and nitrogen.
- Coal is formed when dead plant matter decays into peat and is converted into coal by the heat and pressure due to deep burrial of over millions of years
- Formation of coal seam
  - Insitu theory
  - Drift theory

Drift theory or Allochthonous theory

- According to this theory the plant debris is transported with the flowing water from one place to another and finally gets deposited in the place like swamps, lakes and seas.
- These places have suitable conditions of supply of sediments

Insitu theory or Autochthonous theory

- According to this theory, the areas where the vegetation grew, subsided and the trees were submerged in water which flew into the subsided area.
- They were burried beneath the earth and sand brought by the water.

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Insitu theory or Autochthonous theory

- According to this theory, the areas where the vegetation grew, subsided and the trees were submerged in water which flew into the subsided area.
- They were burried beneath the earth and sand brought by the water.
- Fresh vegetation grew over the debris in the area and this process repeated over thousands of years

Rank of coal

- Rank of coal indicates the carbon content of it
- The heating value of the coal depends on the percentage of hydrogen and carbon
- Anthracite – sp.gr. 1.47
- Bituminous – sp.gr. 1.32
- Sub bituminous – sp.gr. 1.30
- Lignite – sp.gr. 1.2
- The thickest coal seam in India is Jhingurda top seam (130 – 162m). It belongs to gondwana period

Gondwana period

- Gondwana coal makes upto 98% to the total reserves and 99% of the production of coal in India
- The carbon content in Gondwana coal (250million years old) is less compared to the Carboniferous coal (350million years old)
- The Damuda series (i.e. lower gondwana) possesses the best worked coalfields accounting for 80% of the total coal production in India.
- Coking coal as well as non coking coal and bituminous and sub bituminous coal are obtained from Gondwana coal fields
- Anthracite is generally not found in the Gondwana coal fields
- The volatile compounds and ash (usually 13 – 30%) and does not allow carbon percentage to rise above 55 – 60%
- Gondwana coal is free from moisture, but it contains Sulphur and Phosphorus

Distribution of Gondwana coal in India

- First coal mine was opened in 1774 at Raniganj in West Bengal
- Coal industry was nationalized in 1973 – 74.
- India is now the third larges coal producer in the world after China and the USA
- Coal industry provides employment to nearly 7lakh people

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Distribution of Gondwana coal in India

- First coal mine was opened in 1774 at Raniganj in West Bengal
- Coal industry was nationalized in 1973 – 74.
- India is now the third larges coal producer in the world after China and the USA
- Coal industry provides employment to nearly 7lakh people
- Gondwana coalfields are exclusively found in Peninsular plateau of India

Gondwana coalfields in Chattisgarh

- Korba coalfield – Korba district
- Bisrampur, hasdeo, chirmiri, lakhanpur coalfields – Anuppur district
- Jhilmili coalfield – shahdol district
- Johilla coalfield – Johilla valley
- Sonhat, tatapani – ramkota coalfields – Sarguja district

Gondwana coalfields in Jharkhand

- 1st in reserves (28%)
- 2nd in production (20%)
- Oldest and richest coalfields of India
- Coking coal is mainly found over here
- Jayanti coalfields – coal is of inferior quality and high ash content
- Girdih coalfields – finest coking coal of India is found over here
- Huttar coalfields – coal is of low quality and used in cement and brick kiln
- Most of the coalfields are located in a narrow belt running in east – west direction
- Major coalfields are present in Dumka, Hazaribagh, Dhanbad, Palamau
- Jharia, Bokaro, Girdih and Karanpura are the major coalfields

Gondwana coalfields in Odisha

- Talcher coalfields
  - Ranks second in reserves (24,374MT) after Raniganj
  - Coal is suitable for steam and gas production
  - Used by thermal power plants and fertilizer industries at talcher

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Gondwana coalfields in Odisha

- Talcher coalfields
  - Ranks second in reserves (24,374MT) after Raniganj
  - Coal is suitable for steam and gas production
  - Used by thermal power plants and fertilizer industries at talcher

Gondwana coalfields in MP

- Singrauli (waidhan) coalfields
  - Jhingurda, Panipahari, Khadia, Purewa and Turra are the Important coal seams of the area
  - It used in thermal power plants
- Pench, Kanhan and Tawa coalfields
  - Ghoravari seam in kanhan coalfields is 4.6m thick contains coking coal
- Umaria coalfields
  - Coal is of low quality
  - High percentage of ash and moisture

Gondwana coalfields in Andhra Pradesh

- 6th in reserves (7.07%)
- 5th in Production (9.69%)
- Most of the coal reserves are in godavari valley
- Workable collieries are situated at singareni and kothagundam
- Coal is of non coking variety

Gondwana coalfields of Maharashtra

- 3% reserves of India
- 7% production
- Kamptee coalfields in Nagpur districts
- Wun coalfields in Yavatmal districts
- Wardha valley, Ghughus, Ballarpur and warora in chandrapur district

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Gondwana coalfields of Maharashtra

- 3% reserves of India
- 7% production
- Kamptee coalfields in Nagpur districts
- Wun coalfields in Yavatmal districts
- Wardha valley, Ghughus, Ballarpur and warora in chandrapur district

Gondwana coalfields in West Bengal

- 4% of Indias coal production
- 11% of coal reserves
- Darjeeling and jalpaiguri chief producing districts
- Raniganj is the largest coalfields of west bengal
- Non – coking steam coal is found here

Tertiary coal India

- Tertiary coal is 15 – 60 Million years old
- Carbon content is very low
- Mainly confined to the extra – peninsula (J&K, Himachal pradesh, Assam, Arunachal Pradesh)
- Coal generally has low carbon and high percentage of moisture and sulphur.
- Important areas of tertiary coal include parts of Assam, Meghalaya, Arunachal pradesh, Nagaland, Himalayan foothills of Darjeeling, J&K, Uttar pradesh, Rajasthan, Kerala, Tamil Nadu, Pondicherry

Tertiary coalfields in Assam

- Makum, Nazira, Mikir hills, Dilli-jeypore and Lakhuni
- Makum coalfield in sibsagar district is the most developed field.
- Assam coal contain very low ash and high coking qualities but the sulphur content is high, as a result of which this coal is not suitable for metallurgical purposes

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Tertiary coalfields in Assam

- Makum, Nazira, Mikir hills, Dilli-jeypore and Lakhuni
- Makum coalfield in sibsagar district is the most developed field.
- Assam coal contain very low ash and high coking qualities but the sulphur content is high, as a result of which this coal is not suitable for metallurgical purposes
- But these coal are best suited for hydrogenation process and are used for making liquid fuels

Tertiary coalfields in Arunachal Pradesh

- Upper Assam coal belt extends eastwards as Namchick-Narup coalfield
- High in volatiles and in sulphur

Tertiary coalfields in J&K, Himachal Prades

- Kalakot and surrounding region in Jammu, south of Pitpanjal
- Himachal Pradesh – Chamba district

Tertiary coalfields in Meghalaya

- Garo, Khasi and Jaintia hills
- Darrangi field – Garo hills
- Siju, Cherrapunji, Liotryngew, Maolong and Langrin coalfields – Khasi and Jaintia hills

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- Kalakot and surrounding region in Jammu, south of Pitpanjal
- Himachal Pradesh – Chamba district

Tertiary coalfields in Meghalaya

- Garo, Khasi and Jaintia hills
- Darrangi field – Garo hills
- Siju, Cherrapunji, Liotryngew, Maolong and Langrin coalfields – Khasi and Jaintia hills

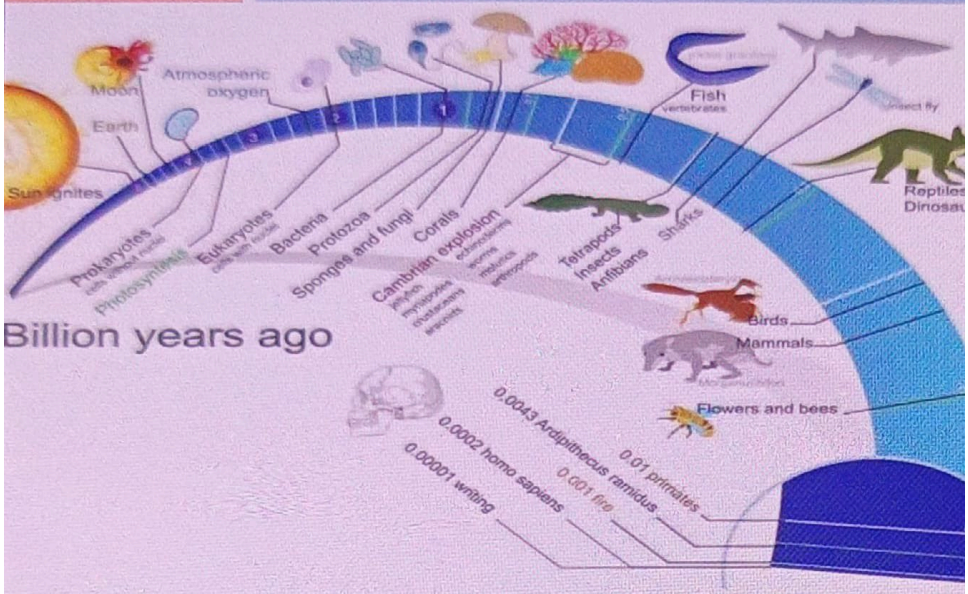
Lignite in Tamil Nadu

- 90% of the reserves
- 57% of the production
- Neyveli Lignite fields of cuddalore district
- These are the larges deposits of lignite in south – east asia
- Neyveli mines suffer from the artesian structure i.e. mining goes deep and deep
- Mining in lignite coalfields is risky due to spontaneous combustion of lignite

Difference between coking and non coking

Coking coal	Non – coking coal
High carbon content, less moisture, less sulphur, less ash	Sulphur content is high and hence cannot be used in iron and steel industry
Used to create coke. Coke is produced by heating bituminous coal without air to extremely high temperatures	Creating coke using this coal is not economical and traces of sulphur will remain even after coking
Coking means flushing out of impurities and improving the concentration of carbon	Thermal coal is used to generate power
It is an essential ingredient in steel production	

Geological time scale



Geological time scale

- It is the chronological order about the evolution of life on earth after the formation of earth
- In this chronological order we study about the relationship between time and various events on earth
- Scientists studied about it by radioactive dating i.e. carbon dating
- They studied by stratigraphy i.e. different layers of earth
- The study is done by International Union of Geological Sciences. Its headquarter is in Paris (France) and established on 1961
- Nomenclature of the time is done by International Commission of Stratigraphy
- Eon – Era – Period – Epoch - Age

Geological Time Scale

EON	ERA	PERIOD	MILLIONS OF YEARS AGO	KEY EVENTS
Phanerozoic	Caenozoic	Quaternary		Humans evolve
		Tertiary	1.6	
	Mesozoic	Cretaceous		
		Jurassic	138	Extinction of Dinosaurs
		Triassic	240	
	Paleozoic	Permian		Permian mass extinction
		Carboniferous	330	
		Devonian	410	
		Silurian		Invertebrates become common
		Ordovician	500	
		Cambrian		
Proterozoic	Also known as Precambrian			
Archean			3500	
Hadean				Earliest life

Eon

- Hadean – Archean – Proterozoic – Phanerozoic
- Hedean, archean and proterozoic are so much old that we don't know about the earth of that time

Eon

- Hadean – Archean – Proterozoic – Phanerozoic
- Hedean, archean and proterozoic are so much old that we don't know about the earth of that time
- It is because at that time fossils were there is not confirmed. And if the fossils were there may be they were destroyed by lava
- If talk about the study of this period by rocks then rocks also got very much deformed. Therefore study is difficult. Eg. – Aravali hills in Rajasthan because earlier it was like mount everest
- Hedean, archean and proterozoic belong to the pre-cambrian period
- Phanerozoic belongs to the cambrian period

Hadean

- 3.8BY – 4.6BY approx 4600 lakh years
- Formation of ocean and continents took place in this period
- During this period atmosphere was rich in carbon di oxide as compare to other gases
- There is an hypothesis that all the gases came out and formed clouds and for several crore years only rain took place on the earth
- Methane gas – Jupiter, saturn, uranus, neptune
- Carbon di oxide – Mercury, venus, mars, earth

Archean and proterozoic

- Archean
  - 2.5BY – 3.8BY
  - First life – Blue green algae
  - A unicellular bacteria
- Proterozoic
  - 0.5BY – 2.5BY
  - Anthropods – Small insects having soft body and they were invertebrates

Phanerozoic

- Eras
  - Palaeozoic (570MY – 245MY)
  - Mesozoic (245MY – 65MY)
  - Cenozoic (65MY – Present)

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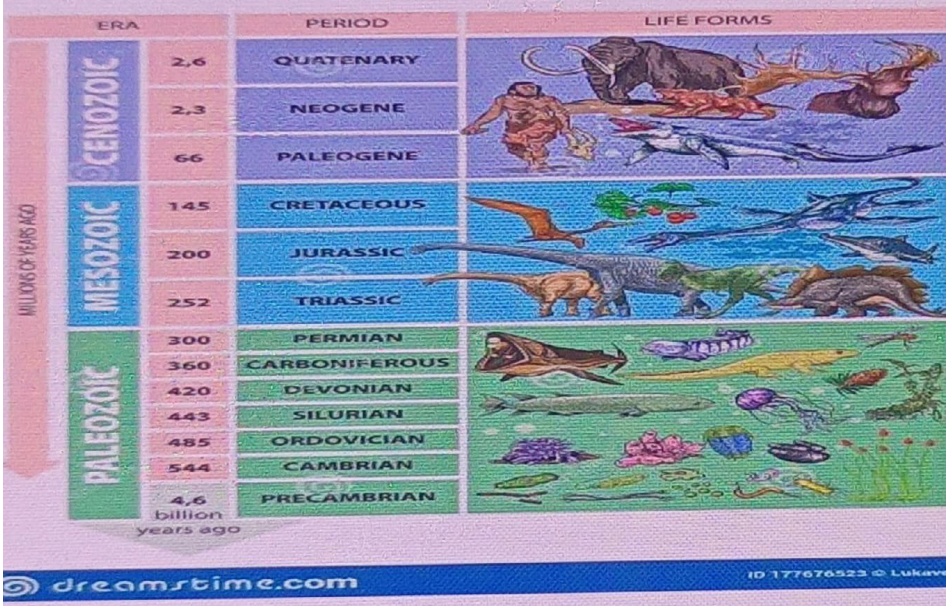

Palaeozoic Era

- Periods
  - Cambrian (570MY – 505MY)
  - Ordovician (505MY – 438MY)
  - Silurian (438MY – 408MY)
  - Devonian (408MY – 360MY)
  - Carboniferous (360MY – 286MY)
  - Permian (286MY – 245MY)

Periods of Palaeozoic Era

- Cambrian
  - No terrestrial life
  - Marine invertebrates were found
- Ordovician
  - First fish arrived
  - This period is also called age of fish
- Silurian
  - Shortest period of palaeozoic era
  - First life on land arrived – Flora i.e.
- Devonian
  - Amphibian – Animals who can live on land and water both
- Carboniferous
  - Longest period of Paleozoic era
  - First reptiles
  - Vertebrates in marine region – Corals
- Permian
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Mesozoic Era

- Periods
  - Triassic (245MY – 208MY)
  - Jurassic (208MY – 144MY)
  - Cretaceous (144MY – 65MY)
- Triassic – Frog, Turtle and Dinosaurs
- Jurassic – Age of Dinosaurs
- Cretaceous – Extinction of Dinosaurs

Cenozoic Era

Tertiary period

- Epochs
  - Palaecene (65MY – 57MY)
  - Eocene (57MY – 37MY)
  - Oligocene (37MY – 24MY)
  - Miocene (24MY – 5MY)
  - Pliocene (5MY – 2MY)

Qaternary period

- Epochs
  - Pleistocene (2MY – 10000Years) – It is the period when Homosapiens arrived
  - Holocene (10000 Years – Present) – Modern men

Tertiary period

- Tertiary period is important for mountain building
- Paleocene
  - Small mammals like rat were found
- Eocene
  - Longest epoch of tertiary period and rabbits were found
- Oligocene
  - Apes were found

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Cenozoic Era

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  - Miocene (24MY – 5MY)
  - Pliocene (5MY – 2MY)

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- Oligocene
  - Apes were found
- Miocene
  - Flowering plants arrived on earth
- Pliocene
  - It is the shortest epoch
  - Human ancestors arrived

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Banded constituents of coal

- The bituminous coal contains 4 different visible bands
  - Vitrain
  - Clarain
  - Durain
  - Fusain
- These are the rock types not chemical entities
- But different vitrains have different chemical compositions
- Subdivisions of these rock types into macerals and petrological units are:-
  - Vitrinite
  - Fusinite
  - Exinite
  - Resinite
  - Micrinite

Banded constituents of coal

- All four bands are not present in the same sample of coal
- Generally only two bands exist
- Vitrain
  - It forms the bright layers
  - Glassy texture
  - It is found in high quality coal
  - It is friable
  - It breaks in small cubes and rectangular pieces
  - It is clean to touch

Continued...

- Clarain
  - It is also in bright layers
  - It is parallel to the bedding plane
  - It does not soil the fingers
  - It resembles vitrain
  - It is present in high quality coal
- Durain
  - It has dull appearance
  - It is lenticular in shape
  - It is hard
- Fusain
  - It has dull appearance
  - It is friable
  - Soils the fingers
  - It is the most impure band of coal
  - The layers resembles charcoal
  - It is present in all types of coal

Coal analysis and commercial grades

- Size gradation of coal
  - Steam coal – 50mm to 200mm
  - Rubble coal – 25mm to 50mm
  - Slack coal – 0mm to 25mm
- Run of mine (ROM) coal

- Quality of coal depends on:-
  - The chemical composition of the original plant
  - The mode of accumulation and burial of the plant debris
  - Inorganic matter that got

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- Run of mine (ROM) coal
  - It is the unscreened coal of all sizes

- Quality of coal depends on:-
  - The chemical composition of the original plant
  - The mode of accumulation and burial of the plant debris
  - Inorganic matter that got mixed in the plant material
  - Extent of decay
  - Age of deposits
  - Geological disturbances

Analysis of coal

Ultimate analysis

- It gives the percentage of elements present
- Like - O_2, N_2, carbon, H_2, sulphur, phosphorus
- It gives suitability of coal for chemical industry purposes

Proximate analysis

- It gives percentage of ash, moisture, volatile matter and fixed carbon
- It gives the percentage by weight

Various constituents of coal

- Ash – it is the inorganic residue left when coal or coke is burned in air to get constant weight
- Moisture – it is the water expelled in various forms when coal is heated
- Volatile matter - Various gases in coal = total loss in weight – moisture when coal or coke is heated
- Fixed carbon = 100 – sum of percentage of moisture, ash and volatile matter
- Free moisture – the free or visible water present on the surface of or in cleavages and cracks
- Inherent moisture – the moisture present inside the coal
- Total moisture – it is the sum of free moisture and inherent moisture

Proximate Analysis

- It gives the percentage of inherent moisture
- Four different methods of proximate analysis
  - Analysis on as-received sample basis
  - Analysis on air dried sample basis
  - Analysis on equilibrated conditions basis

Proximate Analysis

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  - Analysis on as-received sample basis
  - Analysis on air dried sample basis
  - Analysis on equilibrated conditions basis
  - Analysis on unit coal basis or dry mineral matter free basis or pure coal basis

Analysis on as received sample

- It is not a common practice.
- The coal samples have to be collected in sealed containers so that the moisture adhering to the coal is not dried up during transit or storage pending analysis.
- Some power houses attach importance to such analysis to know the real coal and the external moisture adhering to it
- So that payment is made only for the coal to the suppliers.

Analysis on air dried samples

- It is commonly adopted practice.
- An air dried sample is that which is spread in thin layers in a laboratory and exposed to its atmosphere for a few days till its weight is constant.
- Generally 2-3 days suffice, depending upon relative humidity.
- A sample which is spread in thin layers in a laboratory for 6-10 hours and air allowed to pass over it an laboratory temperature and humidity, also attains constant weight and is treated as an air-dried sample.
- Where a large number of samples are to be analysed, a quicker method of getting an air-dried sample is to heat a laboratory sample in an oven to nearly 50°C and keep it at that temperature for 1 ½ to 3 hours.
- In an air - dried sample the external moisture adhering to it dries up, the time depending upon relative humidity.
- Analysis of air-dried sampled can be carried out in most of the laboratories which are not equipped with special chamber having conditions of equilibrated atmosphere.

Analysis on equilibrated conditions

- Reporting analysis on equilibrated conditions basis is a more scientific method. The analysis is done on coal samples passing through IS 20 sieve after equilibrating under the conditions given below for 48 hours.
- Atmospheric temperature = 40° ± 2°C
- Relative humidity = 60% ± 2%
- Only some laboratories are equipped with chambers having such conditions of equilibration.

analysis is done on coal samples passing through IS 20 sieve after equilibrating under the conditions given below for 48 hours.

- Atmospheric temperature = 40° ± 2°C
- Relative humidity = 60% ± 2%
- Only some laboratories are equipped with chambers having such conditions of equilibration.
- This analysis provides a uniform basis for comparision of coals from different parts of the country is local temperature and relative humidity do not affect the moisture percentage in coal analysis.
- Commerical grades fixed by the Govt. of India are based on analysis carried out under equilibrated conditions.
- Coal containing less than 2% moisture are known as low moisture coals; if moisture is more than 2%, it is high moisture coal.

Analysis on Unit-coal basis

- It provides a better way of comparing ranks of different coals.
- The analysis indicates the nature of the coal substance, that is, the pure combustible or organic part of coal, that is to say carbon and volatile matter.
- Moisture and ash do not contribute to the heating capacity of coal
- In this analysis only the volatile matter and fixed carbon are reported as percentages of the coal substance.

Laboratory methods for proximate analysis

- Samples of coal are collected from wagons, trucks or conveyor belts
- The collected sample in subjected to the processes of crushing, coning and quartering.
- These operations are repeated two or three times to get a laboratory sample, usually of 50gm, which can pass through IS 20 sieve.
- For the proximate analysis only 1-5gm of the sample prepared in the aforesaid manner is taken for each test.
- Moisture percentage (by weight) of coal is determined by heating an air-dried sample of coal in a shallow glass dish covered with a ground-glass cover plate at 105°C to 110°C until the weight is constant.
- Loss of weight gives moisture content (inherent moisture).
- Volatile matter is determined by heating a laboratory sample of coal in a muffle furnace out of contact with air for about 7 minutes at a temperature of 925°C.
- Loss of weight gives the weight of moisture and volatile matter.
- Percentage of V.M. is calculated after determining moisture percentage
- Ash percentage is determined after heating a sample of coal in an open silica dish in a well ventilated muffle furnace to nearly 815°C till the weight remains constant.
- The inorganic residue left on the dish is ash.
- Percentage of fixed carbon is obtained by subtracting from 100 the total percentage of ash, moisture and VM.
- The mineral matter = 1.1 x ash percentage.

Grades of coking and non-coking coal

- The existing grades of coals were formulated by the Govt. of India in July 1979
- For non-coking they are based on useful heat value calculated from the results of proximate analysis.
- The calorific value of coal or any fuel can be determined in a laboratory in a bomb calorimeter but in the case of coal it can also be calculated by the formula if the ultimate analysis or proximate analysis results are known.
- Ultimate analysis should give the percentage of carbon, hydrogen, oxygen, nitrogen, sulphur, ash, and moisture.
- The substances which produce heat when a fuel burns are chiefly carbon and hydrogen, and sulphur to a slight extent.
- Any oxygen which may be present causes a loss of heat, because it uses up its equivalent amount of hydrogen, leaving only the excess as a heat producer.
- Moisture in the coal, together with that produced by the combination of any oxygen present, takes up heat in its conversion into steam
- The mineral matter or ash is a non-producer of heat.

Formula to find grade of coal

- Useful heat value = 8900 – 138 (A + M)
- Where,
  - A = ash %
  - M = moisture %
- SI Unit of UHV is kcal/kg
- If the non coking coal contains less than 2% moisture and less than 19% Volatile matter from the value calculated by the above formula, subtract 150kcal/kg for every 1% v.m. below 19% and that gives that actual UHV for the coal
- Grades of coal
  - Grades of coking coal – It is based on ash content
  - Grades of semi-coking and weakly coking coal – It is based on ash content + moisture content
  - Grades of non-coking coal – It is based on Gross Calorific Value (GCV)

GCV & UHV

- GCV = 76.56 – 1.3(VM + Ash) + 0.0073(VM + Ash)
- In Gross calorific value it is assumed that moisture and other elements present in coal (besides coal) can be used for generation of Heat
- In Useful heat value it is assumed that those elements can't produce heat and so are eliminated for the purpose of heat calculation
- Another difference is in bands of grading i.e. GOI divides UHV bands in 7 bands while GCV band was divided in 17 bands
- The interval range is narrow (about 300kcal/kg) so there is least variation in price paid and quality of coal received against a particular grade.
- So it beneficial for consumers as well as supplier

Grade	Ash Content
Steel Grade - I	Not exceeding 15%
Steel Grade -II	Exceeding 15% but not exceeding 18%
Washery Grade -I	Exceeding 18% but not exceeding 21%
Washery Grade -II	Exceeding 21% but not exceeding 24%
Washery	Exceeding 24% but not

Group	V.M.*	Gross C.V. R.H;40°C	Moisture % at 60%
B-4	over 32	8060 - 8440	3 - 7
B-5	over 32	7500 - 8060	7 - 14

Grade	Ash+Moisture

Grades of coal

- Hard coke BH ordinary – ash upto 36%
- Hard coke BH superior – ash upto 31%
- Beehive coke – Coke that is made in a beehive oven and usually of large size and hard structure
- Ungraded coals – The ash or ash + moisture content exceeds the above specifications but such ash or ash + moisture does not exceed 50% of coal.
- Rejects – The coal whose ash or ash + moisture is in excess of 50% of the coal.
- No grades are fixed for coals of Andhra Pradesh (Singareni group of mines).

The proximate analysis of some coal seam

- Kargali top seam (Sawang Colliery) excluding bands, air-dried basis,
  - Moisture % = 0.7-0.8
  - Ash % = 18.4 - 19.7
  - Volatile matter = 28.4 - 30.4
  - Fixed carbon = 62.5 - 49.
- Purewa top seam (Singrauli Coalfield), on equilibrated basis i.e. 60% R.H. & 40°C excluding dirt bands,
  - Moisture % = 5.3 to 8.5
  - Ash % = 22.6 to 40.0
  - Volatile matter = 24.0 to 30.9
  - Fixed Carbon 48 to 21
  - Calorific value kcal/kg. 3300 to 4200.

Barkar and Raniganj coal seams

Barakar coal seam	Raniganj coal seam
Low moisture (1-2%)	High moisture (3-8%)
Low volatile (20-30%)	High volatile (30-60%
High fixed carbon (56-65%)	Medium fixed carbon (50-60%)
Excellent steam coal and coking coal	Poorly coking
	Good gas coal
	Long flame steam coal

Coking coal

- When heated in the absence of air at a temperature more than 600°C, it forms a solid, porous residue called coke
- The coal is carbonised
- The process is known as carbonisation
- There are two processes of coal carbonisation
  - Low temperature carbonisation
  - High temperature carbonisation

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Coal carbonisation process

Low temperature carbonisation

- In this coal is heated in the absence of air to a temperature of about 650°C.
- The coke formed is not strong enough for metallurgical purpose
- It is soft and can be used as domestic fuel
- It is nearly free from smoke
- Neyveli lignite complex
- Ramkrishna in AP with coal input of 900te/day
- Dhankuni in west bengal with coal input of 1500te/day

High temperature carbonisation

- Coal is heated in the absence of air to a temperature of 1000°C – 1100°C
- The gases of combustion are allowed to escape in the atmosphere in beehive coke oven plants
- It is suitable for metallurgical purposes
- It is used as gaseous fuel in the steel plants
- This type of carbonisation is done in beehive coke oven plants or by product recovery plants
- BH coke oven plants – Ena colliery in Jharia fields
- By product recovery plant – Bararee, loyabad, lodna, bhowra in Jharia coalfield

Product	H.T.C.	L.T.C.
Coke	0.70 to 0.74 te Hard Coke with 1-3% V.M.	0.75 to 0.8 te smokeless coke with 8-12% V.M.
Gas	280 m^3 to 360 m^3 of 4000 to 5000 kcal/m^3	110 to 170 m^3 of 6000 to 7200 kcal/m^3
Coal tar	22 / to 45 /	80 / to 110 /
Benzol	45 / to 65 /	80 / to 160 /
Ammonium	Sulphate 11 kg	5 to 6 kg.

Hard coke manufacture in Beehive coke ovens

- There are two types of BH coke oven plants or batteries
  - Ordinary or conventional type (sabji bhatta)
  - English type (tata bhatta)
- Both ovens look alike but the difference lies in manner of circulation inside the oven of the smoke and hot gases resulting from burning of coal
- In English type there are passages for hot gases below refractory brick floor of the coal bed and the coal is better heated within a short period compared to ordinary oven, hot gases and smoke do not circulate before escaping into the atmosphere
- Coking cycle – The burning period of raw coal for conversion into hard coke, called coking cycle.
- In English ovens coking cycle is nearly 36 hours
- In ordinary ovens coking cycle is 72 hours
- English oven – 4 tonne raw coal yield 3 tonne hard coke
- Ordinary oven – 4.5 tonne raw coal yield 3 tonne hard coke
- The capacity of oven varies from 3.5 – 5 tonne of raw coal

	Coke with 1-3% V.M.	coke with 8-12% V.M.
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- The capacity of oven varies from 3.5 – 5 tonne of raw coal
- Ovens are constructed back to back having common chimney
- For economical operation battery should consist of minimum 12 ovens
- Raw coal has to be charged in a crushed form (10mm size) to the ovens

Derivatives from coal

- In a by-product coke oven plant the primary derivatives from coal, by weight, are:-
- Coal tar, 3% yield on coal, approximately i.e. 30 kg/te of raw coal.
- Crude benzole, approx. 0.8% yield on coal.
- Ammonium sulphate, approx. 1.1% yield on coal.
- Crude pyridine production is 0.006%3.yield on coal.
- Hard coke, 0.70 to 0.74 te per te of raw coal.
- The secondary derivatives from the above by-products are napthalene, phenols, creosote oil, benzene, pyridine, etc.

Suitability for carbonisation

- The tests for coking coals cover those properties of coal that usually enter into consideration of its suitability for carbonisation, etc. These are:-
  - Caking Index
  - Proximate analysis
  - Chemical composition of coal ash
  - Fusion range of coal ash
  - Swelling test
  - Plastically test
  - Determination of undesirable salts.

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Washery Grade -III	Exceeding 24% but not exceeding 28%

Group	V.M.	Gross C.V. R.H;40°C	Moisture % at 60%
B-4	over 32	8060 - 8440	3 - 7
B-5	over 32	7500 - 8060	7 - 14

Grade	Ash+Moisture
Semi Coking	Not exceeding 19%

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Washery Grade -II	Exceeding 21% but not exceeding 24%
Washery Grade -III	Exceeding 24% but not exceeding 28%
Washery Grade -IV	Exceeding 28% but not exceeding 35%
Washery Grade – V	Exceeding 35% but not exceeding 42%
Washery Grade -VI	Exceeding 42% but not exceeding 49%

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Grade	Ash+Moisture
Semi Coking Grade -I	Not exceeding 19%
Semi Coking Grade -II	Exceeding 19% but not exceeding 24%

GCV BAND (K.Cal./Kg.)	GRADE
Exceeding 7000	G-1
Exceeding 6700 and not exceeding 7000	G-2
Exceeding 6400 and not exceeding 6700	G-3
Exceeding 6100 and not exceeding 6400	G-4
Exceeding 5800 and not exceeding 6100	G-5
Exceeding 5500 and not exceeding 5800	G-6
Exceeding 5200 and not exceeding 5500	G-7
Exceeding 4900 and not exceeding 5200	G-8
Exceeding 4600 and not exceeding 4900	G-9
Exceeding 4300 and not exceeding 4600	G-10
Exceeding 4000 and not exceeding 4300	G-11
Exceeding 3700 and not exceeding 4000	G-12
Exceeding 3400 and not exceeding 3700	G-13
Exceeding 3100 and not exceeding 3400	G-14
Exceeding 2800 and not exceeding 3100	G-15
Exceeding 2500 and not exceeding 2800	G-16
Exceeding 2200 and not exceeding 2500	G-17

Grades		UHV Range
A	–	Exceeds 6200 Kcals/kg.
B	–	From 5601 to 6200 Kcal/kg.
C	–	From 4941 to 5600 Kcal/kg.
D	–	From 4201 to 4940 Kcal/kg.
E	–	From 3361 to 4200 Kcal/kg.
F	–	From 2401 to 3360 Kcal/kg.
G	–	From 1301 to 2400 Kcal/kg

Grades of coal

- Hard coke BH ordinary – ash upto 36%
- Hard coke BH superior – ash upto 31%
- Beehive coke – Coke that is made in a beehive oven and usually of

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Grades of coal

- Hard coke BH ordinary – ash upto 36%
- Hard coke BH superior – ash upto 31%
- Beehive coke – Coke that is made in a beehive oven and usually of large size and hard structure
- Ungraded coals – The ash or ash + moisture content exceeds the above specifications but such ash or ash + moisture does not exceed 50% of coal.
- Rejects – The coal whose ash or ash + moisture is in excess of 50% of the coal.
- No grades are fixed for coals of Andhra Pradesh (Singareni group of mines).

The proximate analysis of some coal seam

- Kargali top seam (Sawang Colliery) excluding bands, air-dried basis,
  - Moisture % = 0.7-0.8
  - Ash % = 18.4 - 19.7
  - Volatile matter = 28.4 - 30.4
  - Fixed carbon = 62.5 - 49.
- Purewa top seam (Singrauli Coalfield), on equilibrated basis i.e. 60% R.H. & 40°C excluding dirt bands,
  - Moisture % = 5.3 to 8.5
  - Ash % = 22.6 to 40.0
  - Volatile matter = 24.0 to 30.9
  - Fixed Carbon 48 to 21
  - Calorific value kcal/kg. 3300 to 4200.

Barkar and Raniganj coal seams

Barakar coal seam	Raniganj coal seam
Low moisture (1-2%)	High moisture (3-8%)
Low volatile (20-30%)	High volatile (30-60%
High fixed carbon (56-65%)	Medium fixed carbon (50-60%)
Excellent steam coal and coking coal	Poorly coking
	Good gas coal
	Long flame steam coal

Coking coal

- When heated in the absence of air at a temperature more than 600°C, it forms a solid, porous residue called coke
- The coal is carbonised
- The process is known as carbonisation
- There are two processes of coal carbonisation

9:42 0.60 KB/s 5G+ 54

Coking coal

- When heated in the absence of air at a temperature more than 600°C, it forms a solid, porous residue called coke
- The coal is carbonised
- The process is known as carbonisation
- There are two processes of coal carbonisation
  - Low temperature carbonisation
  - High temperature carbonisation

Coal carbonisation process

Low temperature carbonisation

- In this coal is heated in the absence of air to a temperature of about 650°C.
- The coke formed is not strong enough for metallurgical purpose
- It is soft and can be used as domestic fuel
- It is nearly free from smoke
- Neyveli lignite complex
- Ramkrishna in AP with coal input of 900te/day
- Dhankuni in west bengal with coal input of 1500te/day

High temperature carbonisation

- Coal is heated in the absence of air to a temperature of 1000°C – 1100°C
- The gases of combustion are allowed to escape in the atmosphere in beehive coke oven plants
- It is suitable for metallurgical purposes
- It is used as gaseous fuel in the steel plants
- This type of carbonisation is done in beehive coke oven plants or by product recovery plants
- BH coke oven plants – Ena colliery in Jharia fields
- By product recovery plant – Bararee, loyabad, lodna, bhowra in Jharia coalfield

Product	H.T.C.	L.T.C.
Coke	0.70 to 0.74 te Hard Coke with 1-3% V.M.	0.75 to 0.8 te smokeless coke with 8-12% V.M.
Gas	280 m^3 to 360 m^3 of 4000 to 5000 kcal/m^3	110 to 170 m^3 of 6000 to 7200 kcal/m^3
Coal tar	22 / to 45 /	80 / to 110 /
Benzol	45 / to 65 /	80 / to 160 /
Ammonium	Sulphate 11 kg	5 to 6 kg.

Hard coke manufacture in Beehive coke ovens

- There are two types of BH coke oven plants or batteries
  - Ordinary or conventional type (sabji bhatta)
  - English type (tata bhatta)
- Both ovens look alike but the difference lies in manner of circulation inside the oven of the smoke and hot gases resulting from burning of coal
- In English type there are passages for hot gases below refractory brick floor of the coal bed and the coal is better heated within a short period compared to ordinary oven, hot gases and smoke do not circulate before escaping into the atmosphere
- Coking cycle – The burning period of raw coal for conversion into hard coke, called coking cycle.
- In English ovens coking cycle is nearly 36 hours
- In ordinary ovens coking cycle is 72 hours

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Hard coke manufacture in Beehive coke ovens

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- Coking cycle – The burning period of raw coal for conversion into hard coke, called coking cycle.
- In English ovens coking cycle is nearly 36 hours
- In ordinary ovens coking cycle is 72 hours
- English oven – 4 tonne raw coal yield 3 tonne hard coke
- Ordinary oven – 4.5 tonne raw coal yield 3 tonne hard coke
- The capacity of oven varies from 3.5 – 5 tonne of raw coal
- Ovens are constructed back to back having common chimney
- For economical operation battery should consist of minimum 12 ovens
- Raw coal has to be charged in a crushed form (10mm size) to the ovens

Derivatives from coal

- In a by-product coke oven plant the primary derivatives from coal, by weight, are:-
- Coal tar, 3% yield on coal, approximately i.e. 30 kg/te of raw coal.
- Crude benzole, approx. 0.8% yield on coal.
- Ammonium sulphate, approx. 1.1% yield on coal.
- Crude pyridine production is 0.006%3.yield on coal.
- Hard coke, 0.70 to 0.74 te per te of raw coal.
- The secondary derivatives from the above by-products are napthalene, phenols, creosote oil, benzene, pyridine, etc.

Suitability for carbonisation

- The tests for coking coals cover those properties of coal that usually enter into consideration of its suitability for carbonisation, etc. These are:-
  - Caking Index
  - Proximate analysis
  - Chemical composition of coal ash
  - Fusion range of coal ash
  - Swelling test
  - Plastically test
  - Determination of undesirable salts.

Caking index

- It is the representation of caking property of coal
- Maximum ratio of sand to coal in a mixture which is capable of supporting a 500g weight after carbonisation
- The maximum ratio of sand and coal is determined in the laboratory
- It also gives an idea about the capacity of coal to yield coke
- For production of hard coke for metallurgical purposes, the coal should possess caking index of 22
- Coal having a caking index of 22 or more is called prime coking

9:44 KB/s

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- It also gives an idea about the capacity of coal to yield coke
- For production of hard coke for metallurgical purposes, the coal should possess caking index of 22
- Coal having a caking index of 22 or more is called prime coking coal
- Coal having caking index less than 22 are soft and cannot be used for metallurgical purpose

Coking coal should possess

- It should not swell on carbonisation; otherwise walls of coke oven will be damaged.
- It should have low phosphorous (less than 0.15%) and low sulphur (less that 0.6% content).
- it should have carbon content high enough (above 58%) to give coke with minimum 75% carbon.
- it should have low ash content nearly 17 to 18% or below. The maximum ash that can be tolerated in the coke is 22.5%.
- V.M. content should not exceed 26%.
- It should be able to yield coke of certain physical characteristics given below
  - Shatter index - over 85
  - Haven stability - over 40%
  - Porosity-35 to 48% and above
  - Micum index, total on 40 mm, % by wt. (minimum) – 75
  - Bresiau hardness - 80 or over (indicating hard coke)
  - size-38 mm to 160 mm.

Plasticity test and the plastometer

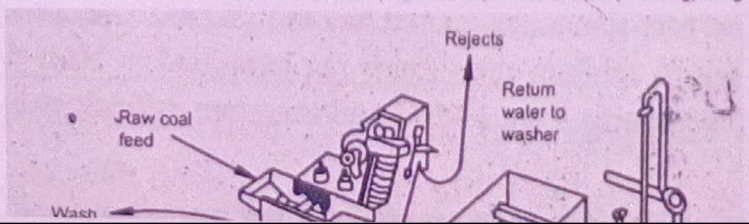
- When heated in the absence of air coking coals first become plastic and then solidify again on further heating.
- On an average the coals soften between 320°C and 350°C, attain maximum fluidity at temperatures between 350°C and 400°C, and solidify again between 400°C and 425°C.
- The temperature of softening and solidifying and the degree of plasticity vary from coal to coal.
- Non coking coal do not show any plastic behaviour.
- Property of coking coal to become plastic on heating in absence of air is known as its Plasticity and it is used as an index of its coking capacity.
- Plasticity tests are generally time-taking and hence they are used mostly for periodical checking of individual coals which go into the oven for carbonisation, and in a steel plant, for the routine testing of one or two coal-mix samples in a day.

Plasticity test and the plastometer

- Plastic property of coal improves on washing.
- Hard coke containing ash 20% or less by wt. is classified as Gr. I coke; more than 20% but less than 24% ash is Gr. II coke.
- The following coal seams produce prime coking coals:
  - Jharia Coalfield - IX, X, XI and upper seams into XVIII seam
  - Giridih Coalfield - Upper Karharbari, Lower Karharbari and Bhadua seam.
  - Raniganj Coalfield- Chanch, Begunia, Laikdih, Shyampur-5, Ramnagar, Khudia.
- Medium coking coal is available from the following coal seams after washing.
  - Jharia Coalfield-V to VIII, Mohuda Top and Mohuda Bottom.
  - Raniganj Coalfield Dishergarh and Sanctoria seams in some areas only.
  - Bokaro and Ramgarh Coalfield - Kargali, Kathara, Sawang, Jarangdih, Bermo, Karo, Uchitdih, Kedla VII and VIII of Ramgarh block one.
  - Kanhan Valley coalfield - Damua Rakhikol.
- Assam coals have very low moisture and low ash (3-7%). They produce excellent hard coke but as they are high in sulphur, their use is not permitted in blast furnaces. Sulphur is present in Assam coals in organic form (3-7%) and therefore difficult to separate (V.M. 35 - 40%).

Coal washing

- The ash percentage in coal can be reduced by a process known as coal washing in coal washeries which are established mostly in Jharia, Raniganj, Bokaro and Karanpura coalfields for treating prime and medium coking coals
- Impurities in coal are plenty and they are collectively known as ash.
- When coal is extracted in underground or opencast mines, external impurities get mixed up with it eg. rock, clay shale and in the case of mines having sad-stowing, sand also gets mixed with coal during mine operations.
- The impurities have higher specific gravities than good burnable coal.
- The operation of washing coal therefore aims at floating the coal and sinking the impurities in water.
- As a matter of fact, coal won't float on water. Coal has specific gravity of 1.28 to 1.3 against 1.0 for water.
- The fact that coal with a specific gravity of 1.28 to 1.3 sinks in water at one speed and its impurities with higher specific gravities sink faster, provides the basic principle for coal washing.
- The difference in settling rates is used in a number of commercial washing devices or washers.
- A fluid mixture of sand (Sp. gr. 2.6) and water in which the sand particles are kept in an agitated form without permitting them to settle, has a specific gravity of nearly 1.60, so that coaly matter floats over such mixture and the impurities settle down.
- This is the principle adopted in Chance coal washer, the first coal washer in India.
- In this process water is pumped into the cone through its sloping sides to produce a rapidly rotating, rising water



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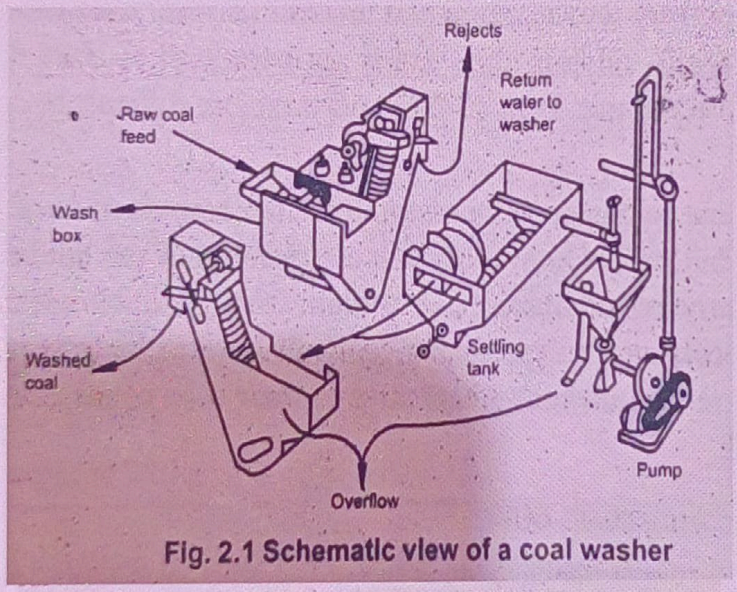

Fig. 2.1 Schematic view of a coal washer

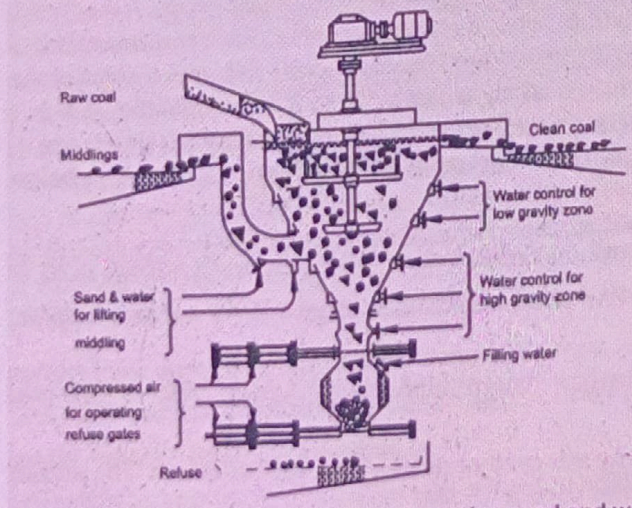

Fig. 2.2 Chance process of coal washing using sand and water

Coal washing

- Raw coal is added to the top of the cone.
- The clean is removed by a weir in the surface of the suspensions and sinks are removed by a lock hopper in the base of the cone
- In another method of washing, the process of Jigging is employed to separate good quality coal from its impurities.
- Jigging is a simple process of particles-stratification in which the particle rearrangement results from an alternate expansion and compaction of a bed of particles by a pulsating fluid flow.

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- Jigging is a simple process of particles-stratification in which the particle rearrangement results from an alternate expansion and compaction of a bed of particles by a pulsating fluid flow.
- The bed of particles is carried on a performed deck through which water passes upward and downward in repeated pulsion and suction stroke (30-50 time per minute) and at the same time the bed is moved forward through the jig chamber in a lateral direction by the horizontal flow of water.
- The stratified bed is cut at various heights by sub surface gates to remove shales and middlings.

Froth floatation

- Ultrafine coal particles of -28 mesh size are cleaned by a process known as froth flotation.
- The process is generally inapplicable to low-rank coals.
- In principle, froth flotation consists of bubbling air through a suspension of fine coal and water to which various chemicals are added with a view to produce stable froth.
- Coal particles attach themselves to the froth but not the particles of rejects because of the preferential physical attachment of air bubbles to coal particles.
- The froth, with the attached coal particles, floats to the surface and is removed.
- The material that forms ash in coal is finely disseminated over the entire coal mass in Indian coals unlike in the coals of other foreign countries like Britain, Germany, U.S.S.R., etc.
- To separate the ash from the heat-producing coaly material, the coal is crushed to a small size along with attached extraneous impurities, before feeding to the washer.
- After washing, the end products are washed (also called clean) coal, middlings, and rejects in a 3-products washery and only washed coal and rejects if it is a two-product washery.
- The clean coal has much less ash percentage compared to that of the raw coal and it is despatched to steel plants for use in ovens.

Uses of coal

- Chief use of coal in industry is as a fuel for steam raising in the boilers in power houses and locomotives, gas producers, brick kilns, furnaces and for household purposes in the form of soft coke.
- Boilers of railway locomotives and most of the Lancashire boilers used for steam raising are fitted with fire grates which are suitable for coal of large size.
- Hence coal over 50 mm in size is called steam coal; coal of 25 mm to 50 mm in size is called rubble coal. Slack coal is that which is smaller than 25 mm in size though sizes upto 50 mm are also sometimes called slack coal.
- Run-of-mine coal is that which is not screened or sized and therefore contains steam, rubble and slack sizes.

Coal washeries in India - Existing

- Prime coking
  - Jamodoba (TISCO) 1.72
  - Lodna (BCCL) 0.40
  - Durgapur (HCL) 1.50
  - Dugda-I (BCCL) 2.40
  - Bhojudih (BCCL) 2.00
  - Patheridh (BCCL) 2.0
  - Durgapur (DPL) 1.35
  - Chasnala (IISCO) 2.00)
- Medium coking
  - West Bokaro (TISCO) 0.57
  - West Bokaro, new (TISCO) 1.80
  - Karagali (CCL) 2.32
  - Kathara (CCL) 3.00
  - Sawang (CCL) 0.75
  - Gidi (CCL) 2.84
  - Barora (BCCL) 0.42
  - Nandan (WCL) 1.20

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Coal washeries in India - Existing

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  - Lodna (BCCL) 0.40
  - Durgapur (HCL) 1.50
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  - Chasnala (IISCO) 2.00)
  - Dugda-II (BCCL) 2.40
  - Sudamdih (BCCL) 2.00
  - Monidih (BCCL) 2.00
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  - Karagali (CCL) 2.32
  - Kathara (CCL) 3.00
  - Sawang (CCL) 0.75
  - Gidi (CCL) 2.84
  - Barora (BCCL) 0.42
  - Nandan (WCL) 1.20
- Non-coking
  - Nowrazabad (WCL) 0.5
- Total installed capacity 33.57 Mte

Coal washeries in India - Proposed

- Prime coking
  - Madhuband (BCCL) 2.5
  - Bhalgora-I (BCCL) 2.5
  - Pootkee (BCCL) 3.0
  - Dharmal-and-1 (BCCL) 2.5
  - Dharmaband-II (BCCL) 2.5
  - Bhalgora-II (BCCL) 2.5
  - Mukunda (BCCL) 4.0
- Medium coking
  - Bharatpur (SECL) 3.50
  - Jhingurdha (NCL) 3.00
  - Bina (NCL) 4.50
  - Jagannath (SECL) 2.00
  - South Balanda (SECL) 1.65
  - Mukunda (BCCL) 5.0
  - Rajmahal (ECL) 10.0
  - Kalinga (SECL) 5.0
  - Ananta (SECL) 3.0
  - Piparwar (CCL) 5.0
  - Dudhichua (NCL) 5.0
  - Selected Dhori (CCL) 2.25
  - Kakri (NCL) 2.50
  - Jayant (NCL) 7.0
  - Khadia (NCL) 5.0
  - Nigahi (NCL) 5.0
  - New Majri (WCL) 1.0
  - Lajkuara (SECL) 1.00

Gaseous fuels

- Gases produced from coal during carbonisation, if recovered in a by-product recovery plant, can be used for production of many chemicals, explosives, plastics, inks, paints, perfumes, fertilizers (eg. at Talcher Fertilizer Plant) and also used for production of synthetic petrol. The gaseous fuels available form coal/coke are:-
- Coke oven gas
- Producer gas
- Water gas
- Coal gas or coke oven gas

Coal gas or coke oven gas

- It is the process of manufacture involves complete gassification of coal subject to the limitations of the plant utilised for manufacture.
- The carbonisation is carried out by heating the coal in the absence of air in horizontal or vertical retorts if gas is the desired major product, or in the coke ovens if coke is the major product required.
- Either method produces gases with similar compositions and a solid residue with an ash content that is higher than the original coal.
- The main differences in the gas making processes are in the quality of coke and in the quantity and characteristics of by-products.

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- Either method produces gases with similar compositions and a solid residue with an ash content that is higher than the original coal.
- The main differences in the gas making processes are in the quality of coke and in the quantity and characteristics of by-products.
- Typical analysis (% by volume) after the gas is washed is as follows: CO= 5.8; CO, 1.5; N, 1.0; H, 57.6; HS = 0.7: CH, 29.6; CH1.3; C,H,2.5.

Heat value

- Heating value of coal gas and coke oven gas is between 4000 and 5000 kcal/m^3.
- Such high heating value makes its transport over long distances, all its gas supply from the coke oven plant of Durgapur in 300 mm dia. pipes.
- Coke oven gas is produced in large quantities at integrated steel plants making their own hard coke in coke oven battries.
- The coke is used in the blast furnaces, and the coke oven gas along with blast furnace gas (heating value of B.F gas nearly 850 kcal/m^3), supplies heat energy for the plant functions.

Producer gas

- It is formed by blowing a mixture of steam and air through a bed of hot coal and therefore its nitrogen content is very high and its heating value low.
- Because of its low heating value it is not transported any great distance and is used within or near the plant that produces it.
- Gross heating value of producer gas manufactured from bituminous coal normally ranges from 1250 to 1600 kcal/m^3.
- Range of gas composition is as follows (% by Vol.) CO = 20 – 30; H_2 = 8 – 20; CH_4 = 0.5 – 3; CO_2 = 3 – 9; N_2 = 50 – 56; 0_2 = 0.1 – 0.3
- Producer gas contains both flammable and non flammable gases

Water gas

- Water gas is made in a manner similar to producer gas except that steam only is passed through the hot carbonaceous material.
- Hot air is first blown through the fuel bed to raise the fuel bed temperature to the desired level and steam is blown through until the temperature drops sufficiently to virtually stop the reaction.
- Then air is blown through it again to increase the bed temperature.
- Because water gas is made up mainly of H_2 and CO, it burns with a

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Water gas

- Water gas is made in a manner similar to producer gas except that steam only is passed through the hot carbonaceous material.
- Hot air is first blown through the fuel bed to raise the fuel bed temperature to the desired level and steam is blown through until the temperature drops sufficiently to virtually stop the reaction.
- Then air is blown through it again to increase the bed temperature.
- Because water gas is made up mainly of H_2 and CO, it burns with a characteristic blue flame.
- Heating value is approximately 2600 kcal/m^3.
- Analysis% by vol: $CO_2 = 5.1$; $CO = 40.2$; $H_2 = 50.0$: $CH_4 = 0.7$; $N_2 = 4.0$
- Water gas contains flammable gases only

Petrol from coal

- There are various processes to derive petrol from coal
  - Hydrogenation of coal – Bergius process
  - Solvent extraction of coal – Pott broche process
  - Hydrogenation of tar obtained from pyrolysis/carbonisation of coal – Fischer Tropsch process

Bergius process

- It is a method for the production of liquid hydrocarbons
- Such as – gasoline, diesel, jet fuel for use as synthetic fuel.
- This method was developed by friedrich bergius
- The process involves the hydroliquefication of brown coal i.e. lignite into crude oil.
- The brown coal is fine powder and heated at 425 – 480°C under 200 – 700 atm pressure of hydrogen gas in the presence of catalyst.
- Catalyst – iron, molybdenum and tin

Coal reserves

- The quantity of coal available in a coal seam in-situ is called its reverses which are generally expressed upto a specified depth.
- Proved reserves
  - These are reserves estimated from dimensions of the coal seam revealed in outcrops, trenches, mine workings and boreholes by assuming their continuity of geological evidence for a distance upto 200 m from the point of observation.
  - A reserve is considered as proved reserve if it is probable that at least 90% of the resource is recoverable by economically profitable means

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- This method was developed by friedrich bergius
- The process involves the hydroliquefication of brown coal i.e. lignite into crude oil.
- The brown coal is fine powder and heated at 425 – 480°C under 200 – 700 atm pressure of hydrogen gas in the presence of catalyst.
- Catalyst – iron, molybdenum and tin

Coal reserves

- The quantity of coal available in a coal seam in-situ is called its reverses which are generally expressed upto a specified depth.
- Proved reserves
  - These are reserves estimated from dimensions of the coal seam revealed in outcrops, trenches, mine workings and boreholes by assuming their continuity of geological evidence for a distance upto 200 m from the point of observation.
  - A reserve is considered as proved reserve if it is probable that at least 90% of the resource is recoverable by economically profitable means
- Indicated reserves
  - These are determined by taking an area of 1000 m x 1000 m for each point of observation where coal seam is indicated. This may be extended to2000 m x 2000 m for known geological continuity.
- Inferred reserves
  - This is an estimate of coal based largely on broad knowledge of geological character of beds but for which there is at measurement.

Mineable or extractable reserves

- The mineable reserves or extractable reserves are those which can be economically extracted with the present knowledge of technology and with due regard to mining Acts and Regulations
- For example, in working a coal mine solid coal has to be left in-situ in the following cases.
- Vertically below towns, railways, canals, lakes, rivers, buildings, public roads and other important surface features and installations and 50 m beyond if not stowing of underground mines is possible
- Below and above a coal seam on fire
- For protection of shaft pillar, panel barriers and roadways which have to be maintained till the life of the underground mine.
- Underground barriers against accumulations of water, gas or fire areas.
- Barrier of coal against railway, road, river, canal, town, etc. in opencast mines. Coal is also blocked up at the boundar of an opencast mine as the quarry sides have to be sloping or kept in the form of long benches or long steps.
- Barrier at the common boundary of adjacent mines.
- Barrier near a fault; burnt or inferior coal near dykes, sills, etc.
- Mineable reserves cannot be extracted cent percent and some loss in inevitable in the methods of mining adopted so that the total production available from a coal seam many vary from 50 percent to 90 percent of mineable reserves. I the calculation of reserves shale or dirt bands 50 mm and above are excluded, but if highly mechanised opencast min are planned

Need of drilling holes

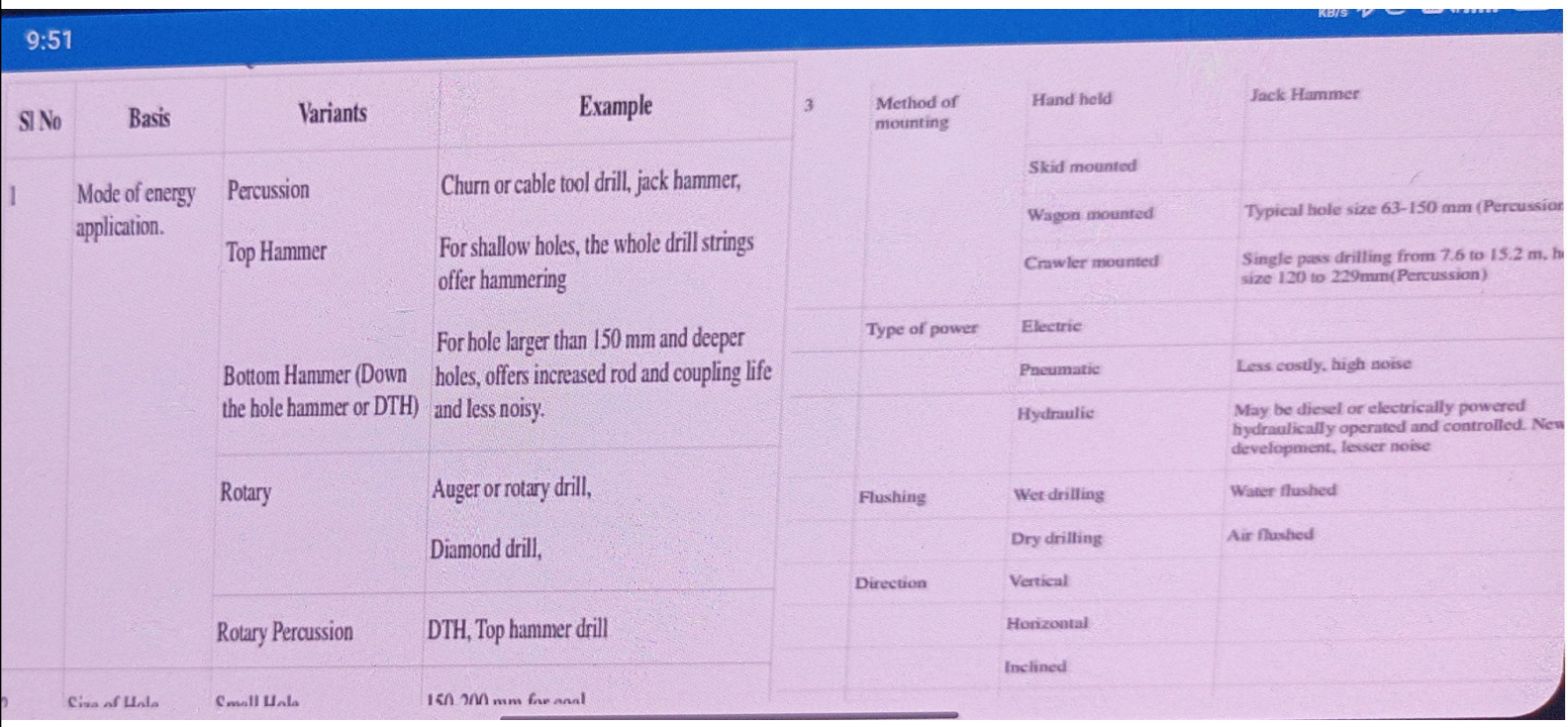
- To prove the existence of minerals
- To get core of the rocks from which bearing pressure of the ground can be found out.
- To know throw of the faults
- To drain off gas or water from old workings
- To carry electric cables, signal wires, stowing pipes or water pipes to the underground from surface.
- To have tube wells for water supply to colonies.
- To blast rock/mineral in a mechanised quarry where holes of 9 to 18 m depth and 125 to 300 mm in dia may be drilled.
- To inject cement in cementation method of shaft sinking
- For ventilation of underground mine workings.
- An interesting application of bore holes drilled from the surface to seal off with incombustible material underground fire and thereby to quench it, was witnessed at Kurasia colliery (M.P.) in 1961.
- Sizes of drill holes drilled in mining areas usually vary from 25 mm to 125 mm though larger diameter holes may be required for carrying stowing pipes, water pipes, or for blasting in mechanised quarries.
- For deep holes, the size is larger at the start and is gradually reduced with depth.

360-DTH Drilling Rig

Methods of drilling

- Percussive drilling
- Rotary drilling
- The percussive method is further sub-divided as
  - Drilling by rigid rods
  - Rope drilling, also known as cable drilling or churn drilling.
- The rotary method may be used with a view to get a core of the rocks passed through or simply to drill a hole, and this decides the type of drilling tool used.
- The rotary method is subdivided as
  - Drilling by saw toothed cutter
  - Drilling by tri-cone rock roller bit
  - Drilling by diamond drill bit
  - Drilling by chilled shots.

Sl No	Basis	Variants	Example
1	Mode of energy application.	Percussion	Churn or cable tool drill, jack hammer,
		Top Hammer	For shallow holes, the whole drill strings offer hammering
		Bottom Hammer (Down the hole hammer or DTH)	For hole larger than 150 mm and deeper holes, offers increased rod and coupling life and less noisy.
		Rotary	Auger or rotary drill,
3	Method of mounting	Hand held	Jack Hammer
		Skid mounted	
		Wagon mounted	Typical hole size 63-150 mm (Percussion
		Crawler mounted	Single pass drilling from 7.6 to 15.2 m, h size 120 to 229mm(Percussion)
	Type of power	Electric	
		Pneumatic	Less costly, high noise
		Hydraulic	May be diesel or electrically powered hydraulically operated and controlled. N development, lesser noise
	Flushing	Wet drilling	Water flushed



Sl No	Basis	Variants	Example
1	Mode of energy application.	Percussion	Churn or cable tool drill, jack hammer,
		Top Hammer	For shallow holes, the whole drill strings offer hammering
		Bottom Hammer (Down the hole hammer or DTH)	For hole larger than 150 mm and deeper holes, offers increased rod and coupling life and less noisy.
		Rotary	Auger or rotary drill,
			Diamond drill,
		Rotary Percussion	DTH, Top hammer drill
2	Size of Hole	Small Hole	150-200 mm for coal
3	Method of mounting	Hand held	Jack Hammer
		Skid mounted	
		Wagon mounted	Typical hole size 63-150 mm (Percussion
		Crawler mounted	Single pass drilling from 7.6 to 15.2 m, h size 120 to 229mm(Percussion)
	Type of power	Electric	
		Pneumatic	Less costly, high noise
		Hydraulic	May be diesel or electrically powered hydraulically operated and controlled. New development, lesser noise
	Flushing	Wet drilling	Water flushed
		Dry drilling	Air flushed
	Direction	Vertical	
		Horizontal	
		Inclined	

		Rotary	Auger or rotary drill, Diamond drill,
		Rotary Percussion	DTH, Top hammer drill
2	Size of Hole	Small Hole	150-200 mm for coal
		Large Hole	250-315 mm for OB
		Very Large Hole	> 315 mm for dewatering well

Flushing	Wet drilling
	Dry drilling
Direction	Vertical
	Horizontal
	Inclined
On board Facilities	With Measure while drilling (MWD) and automated Drill Monitoring (ADM)
	Without measure while drilling
	With automation
	Semi automatic

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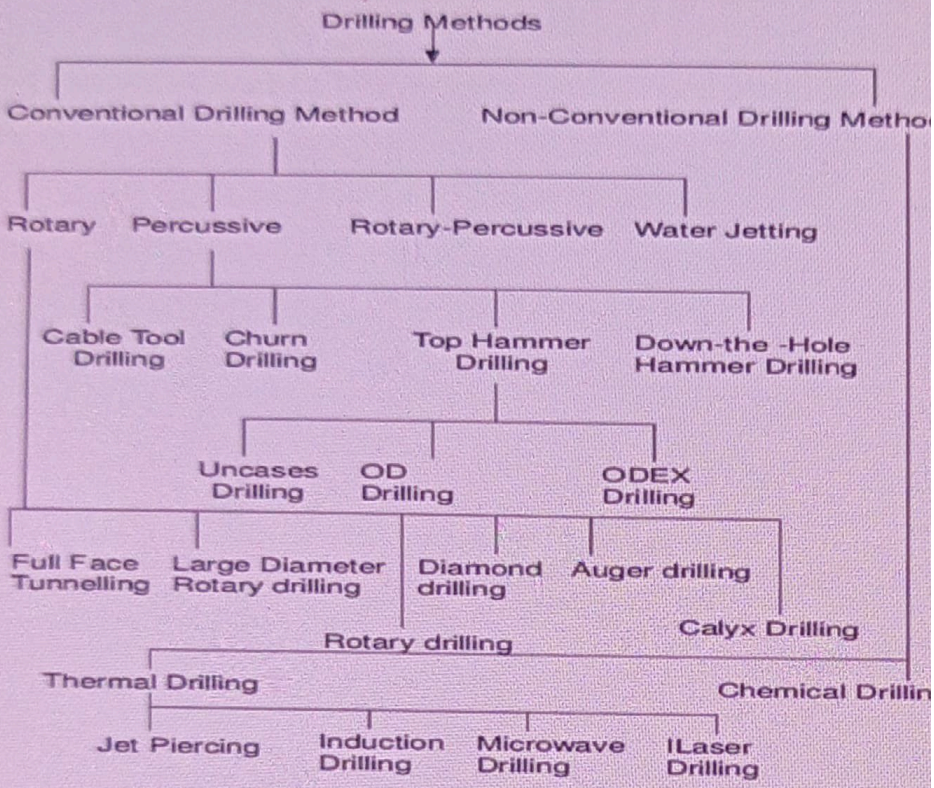
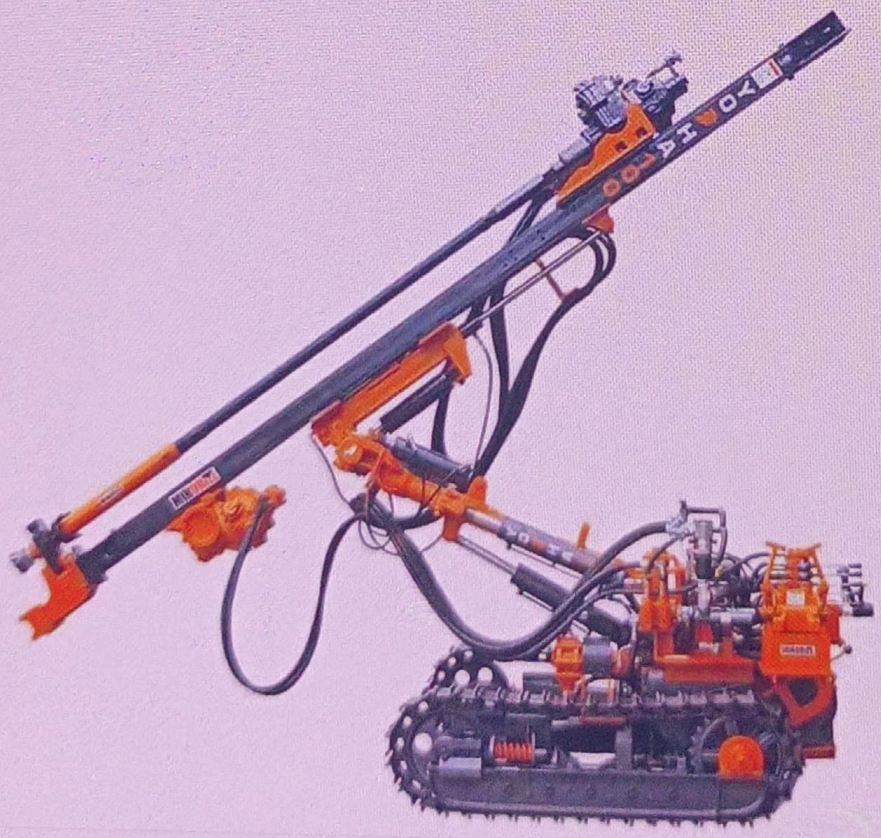


Figure 1 Classification of Drilling Methods



ussive drilling

ich is the oldest one of drilling, the hole is drilled by striking a number at short in inter
l and between the blows the tool is rotated slightly.

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e chisel is suspended from the surface by rods or wire rope and the weight of the chis
e striking force.

Cr or carbon steel.

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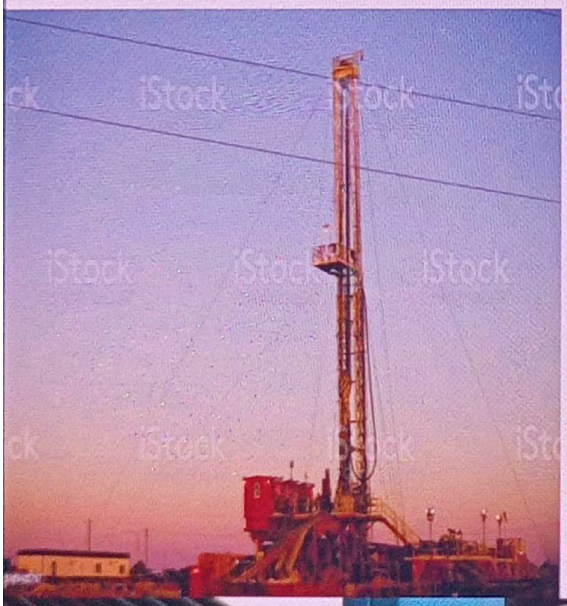
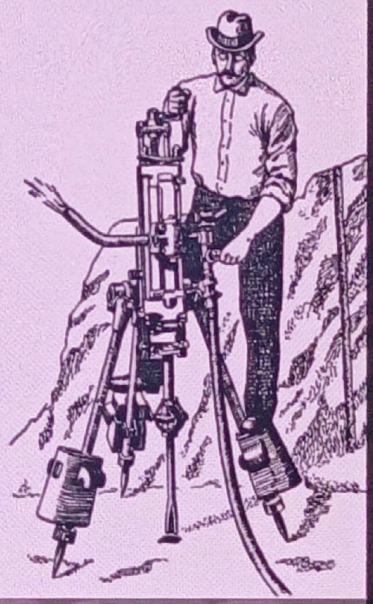
Percussive drilling

- In this method which is the oldest one of drilling, the hole is drilled by striking a number at short in intervals on the rock by a chisel-type tool and between the blows the tool is rotated slightly.
- The rock is chipped away with each blow and a circular hole is formed.
- During drilling the chisel is suspended from the surface by rods or wire rope and the weight of the chisel, rods, etc. is utilised to give the striking force.
- Drilling with rods
- The rods are Ni-Cr or carbon steel.
- Each rod has a male screw at one end and a female -screw (screwed socket) at the other.
- Length of steel rods is 3m with nearly 38 mm x 38 mm square cross section.
- For soft surface deposits which consists of alluvium, clay auger and worm auger may be used.
- These are given a rotary rather than a percussive motion.
- The straight chisel is commonly used for hard strata and the V chisel and T chisel, for very hard strata.
- Every type of drilling requires a derrick which may consist of three or four legs and may be of wood or tubular steel.
- Derrick is used chiefly for lifting the rods from the hole
- In the mining localities, some bad drilling contractors undertake percussive drilling of dia 50 mm to 75 mm holes upto a maximum of 25 m depth with the help of rods without installing any derrick.





Manual drilling

- In this water is not supplied through hose pipes under pressure and the cranck operated beam is replaced by a rocking lever connected to the drill rods.
- The drilling rods are given a percussive motion with the help of a corking level to which they are attached through a stirrup and a brace-head.
- A brace-head is simply a pair of crossed handles fixed to the end of a short top rod
- Two or three men press down the free end of the rocking lever thereby lifting the rods while one man turns them slightly by means of the brace head.
- The men then let go the free end so that the rods fall and the drilling tool gives a blow on the rock.
- Water is poured in the hole at intervals and the process is repeated

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- The men then let go the free end so that the rods fall and the drilling tool gives a blow on the rock.
- Water is poured in the hole at intervals and the process is repeated.
- Short rods are added till the depth drilled by such small rods is slightly more than the length of full-length rod and the short rods are then replaced by a full-length rod.
- Retaining key:- It is a device used at the time of raising or lowering the rods of square cross section.
- Bulldog safety clamp:- It is a device used for raising and lowering of circular cross section rods.

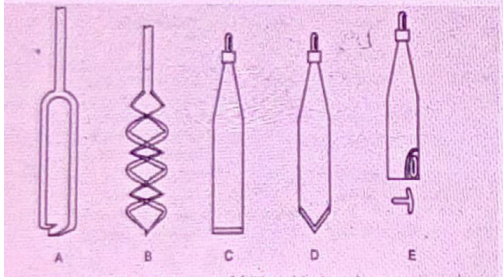
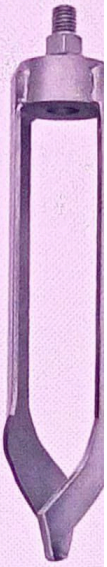
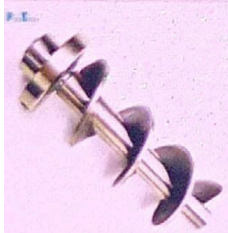
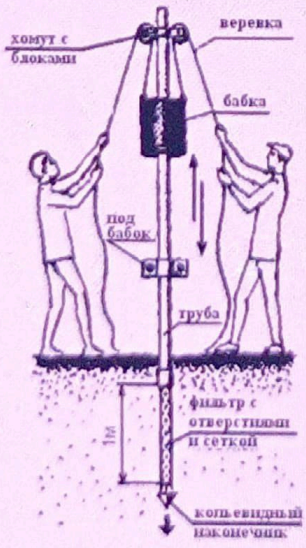
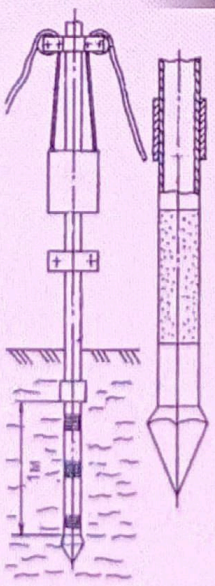


Fig. 3.1 Common types of drilling chisels and augers.
) Clay auger (B) Worm auger (C) Straight chisel (D) V-chisel (E) T-chisel









Sludger

- During drilling the bottom of the hole soon gets filled with cuttings and has to be cleaned out frequently.
- This is done with the help of a sludger which consists of a long cylinder or pipe, open at the top and with a flap valve at its lower end.
- The flap valve opens upwards.
- When attached to the end of the rods and worked up and down the sludger gets filled with the sludge.
- It is then withdrawn to the surface and the process repeated till the hole is cleaned.

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Sludger

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- The flap valve opens upwards.
- When attached to the end of the rods and worked up and down the sludger gets filled with the sludge.
- It is then withdrawn to the surface and the process repeated till the hole is cleaned.
- The cuttings brought to the surface in the sludger give an indication of the rock being drilled.
- The bottom of the drill hole is always kept full with water during drilling

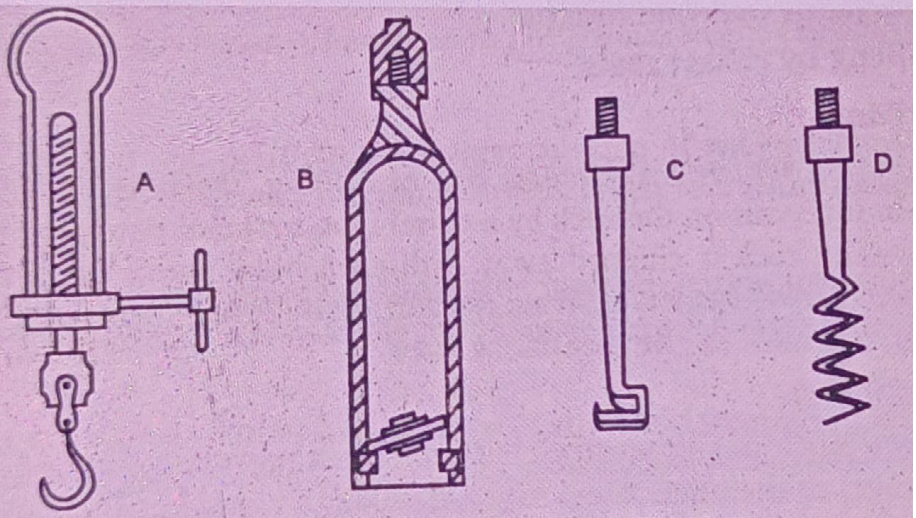

Fig. 3.2. (A) Stirrup and screw. (B) Sludger (C) Crow's foot (D) Sprial worm

Fishing the borehole

- Devices like the crows foot and the spiral worm may be used to catch the broken rod under a joint in the borehole
- Broken pieces of chisel are sometimes raised with the help of powerful magnets
- In diamonds drilling, described later, the diamonds sometimes become loose and fall in the hole.
- The operation of tracing the broken and lost parts in the hole and withdrawing them to the surface is known as ***fishing the borehole***

Lining a drill hole

- During drilling a steel pipe is used for lining the drill hole from surface upto the hard rock, and the drilling tool and rods pass through the pipe
- Obviously, the length of the drill-hole upto which the lining pipe has to be fitted should be of a larger diameter.
- The lining pipe is generally withdrawn after the hole is completed though it may sometimes be necessary to leave it in its position to prevent caving of sides, e.g. drill hole for stowing, water pipes, etc.
- The lining is done by hammering first a special steel pipe with a cutting

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Lining a drill hole

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- The lining pipe is generally withdrawn after the hole is completed though it may sometimes be necessary to leave it in its position to prevent caving of sides, e.g. drill hole for stowing, water pipes, etc.
- The lining is done by hammering first a special steel pipe with a cutting edge. Pipes of 6m lengths and having screwed joints are added to that pipe.

Power drilling with rods

- Drilling with manual labour without the help of power is suitable for holes upto 150 mm in diameter and upto a depth of 30 m or so.
- Beyond that depth, it is impossible to drill with the use of power from a diesel or petrol engine
- Vertical boilers have sometimes been used to avail of steam power
- A power operated winch is used to raise and lower and the rods.
- The walking beam is operated by a crank through gearing from an engine to give the drilling tool 25 to 30 blows per minute and a stroke of nearly 225 mm.
- The rods are attached to the rope with a swivel attachment and bracehead.
- Water is forced down the hole of the hollow drill rods by a pump to keep the cutting tool cool.
- Such water returns to the surface from the outside of the rods with the sludge
- Water flushing eliminates the use of sludger.

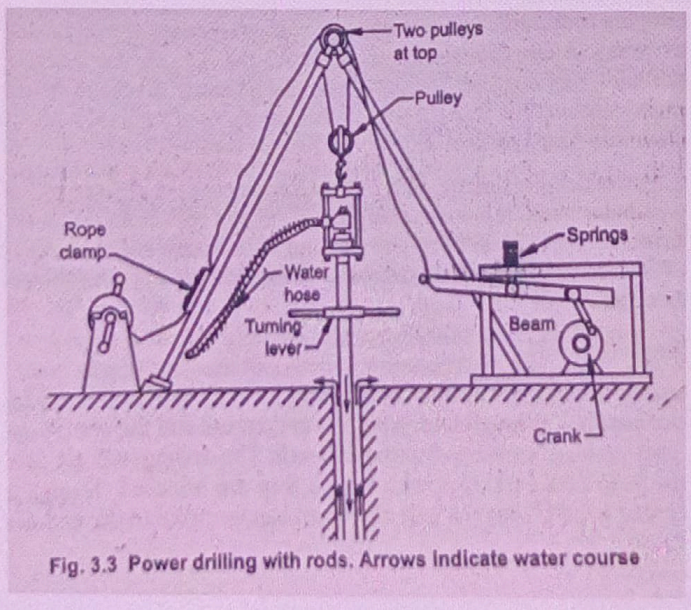

Fig. 3.3 Power drilling with rods. Arrows indicate water course

Rope drilling or cable drilling

- Where the percussive method of drilling is employed cable drilling is commonly adopted for holes deeper than 30 m.
- In this system the rigid rods are replaced by a steel wire rope to which the drilling tool is attached.
- The surface arrangement is practically the same as for drilling with rods, but the end of the walking beam is attached to a temper screw
- The rope from a winch is taken to the clamps of the temper screw across the pulley of the derrick
- Feed of upto 1.2 m is possible with the use of the temper screw.
- When no more feed is possible the temper screw is run back and the rope reclamped 1.2 m higher up.
- During rope drilling no device is necessary to give a twist to the drilling tool between successive

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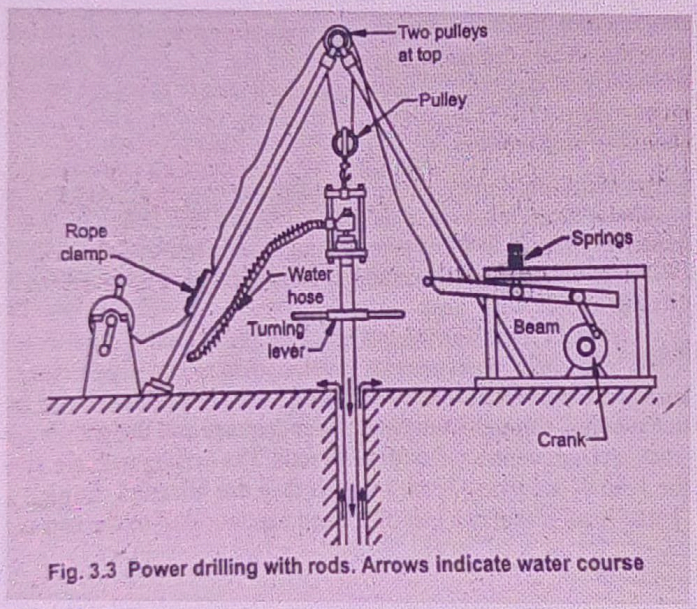

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- When no more feed is possible the temper screw is run back and the rope reclamped 1.2 m higher up.
- During rope drilling no device is necessary to give a twist to the drilling tool between successive blows as the lay of the stranded rope causes the tool to twist slightly.
- The steel rope may be 18 mm diameter for a depth of 300 metres. The ropes have always a left-hand lay, so that the spin of the rope which tends to rotate the drilling tool also tends to tighten the joints between them.
- Cable drilling is also known as churn drilling

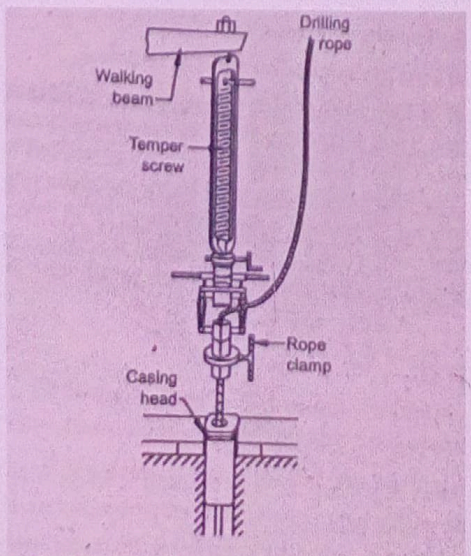


Fig. 3.4 Rope attachement in churn drilling

Rotary drilling and diamond drilling

Rotary

- For rotary drilling, hollow drill rods of steel or aluminium are used.
- These are thread connected and transmit torque and feed pressure to the drilling bit which is attached at the end of a column of the drill rods.
- Rotation of the drill rods is through gearing driven by a prime mover at the surface.
- As the rods rotate, the drilling tool abrades the rock and the cuttings are cleared by pumping water under pressure or compressed air down the hole through the hollow drill rods.
- In some drillings, spedally those for oil exploration, mud which is not very viscous, is circulated instead of water. The mud which keeps back any water, gas or oil pressure encountered during drilling is known as bentonite, aquagel, etc.
- Bentonite or aquagel fills the fractured or friable zone
- The couplings, which are the parts most exposed to wear, are made of chromium-nickel steel.
- Aluminium rods offer numerous advantages, such as increased machine capacity, easier handling, more rapid and simple recovery of the drill string and faster rotation, all of which contribution to simplifying drilling and reducing costs.
- The various methods of rotary drilling are known by the type of drilling tool used but the diamond drilling method is quite common.

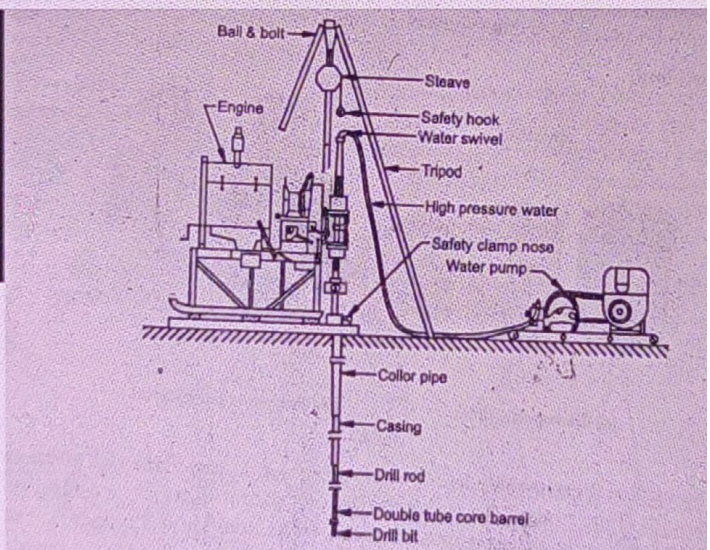


Fig. 3.6 Surface Arrangement for Rotary Drilling

Diamond drilling

- This method is commonly adopted where cores of rocks are desired for accurate records of the strata or for testing the rocks for their strength, composition, porosity, etc.
- Drill bit consists of a cylindrical cast steel shell having in its lower face a number of small sockets in which pieces of black diamonds are set.
- These diamonds are not useful as jewellery but are used in the drill bits for their hardness and the bit is suitable for the hardest rocks.
- The hole sizes in diamond drilling are designated as NX, BX, AX, and EX.
- The drill rods and the drill bits are specified under two main groups, X series and W series, as per the standards laid down by DCDMA (Diamond Core Drill Manufacturer's Association), an international Association.
- The drill hole diameters and core sizes (in mm) available are given below.

	Drill rod outside dia.		

Standard	Drill rod outside dia.		Hole dia. mm	Core dia. mm.
	X series in inches	W series in mm.		
NX....	2.3/8	NW – 67	75	54
BX	1.29/32	BW – 54	60	40
AX	1.5/8	AW – 44	47	28
EX....	1.5/16	EW – 35	38	21

Surface arrangements for diamond drilling

- a derrick
- an engine for supplying power
- an winch
- pump for supplying water under pressure for flushing
- a setting tank
- a platform for keeping the drilling rods lifted for removal of core or changing the bit
- core boxes for keeping the cores
- a driving and feed mechanism for the drill rods.
- The diamond drill bit is rotated at a speed of nearly 300 r.p.m. and the pressure on the diamonds is between 1.5 and 2 kgf/cm^2.
- The pressure acting upon the diamonds of the drill bit and the rate of advance of the drill bit into the rock are controlled by an arrangement known as "feed mechanism.
- The feed mechanism is hydraulic for deep holes and screw feed for shallow holes.
- Beyond a depth of nearly 60 m. the weight of the rods keeps the bit pressed against the rocks and the feed mechanism may not be necessary.
- At greater depth the feed mechanism is operated in such a way that the weight on the drill bit is not excessive.

Screw Feed

- On smaller machines, driven either by hand-power or mechanically, the feed is by a screw feed arrangement comprising a series of differential gears.
- In this arrangement the drill rods pass through a hollow screw shaft, threaded on the outside, and provided with a long keyway.
- Usually three different combinations of gear are provided here, any of which can be utilised to vary the rate of advance to suit the type of rock.
- Gear A engages the gear B, through the counter-shaft, drives C, which engages a fourth wheel D, threaded internally to fit the threads of the screw shaft.
- The number of teeth on gears A, B, C and D are 38, 36, 24 and 25
- One revolution of A = 38/36 revolution of B and C, = 3/836 x 24/25, revolutions of D.
- Therefore 75 revolutions of A will cause D to rotate 75 x 38/36 x 24/25= 76 times.
- Consequently for every 75 revolutions of A,D revolves 76 times, and the screw shaft moves forward by a distance equal to the pitch of its thread.
- If this is 6 mm, then the rods advance 24 mm for every 300 revolutions.
- The movement of the screw shaft is imparted to the rods by the chuck.
- A pressure gauge attached to the roller friction collar records the varying pressure on the bit.

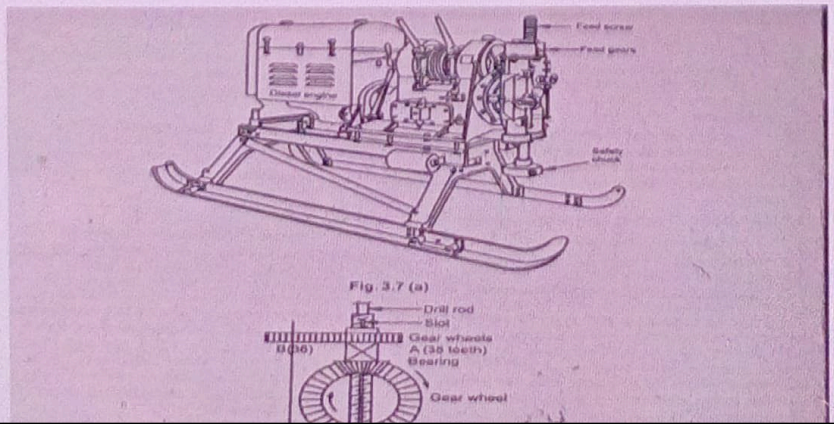


Fig. 3.7 (a)

- A pressure gauge attached to the roller friction collar records the varying pressure on the bit.

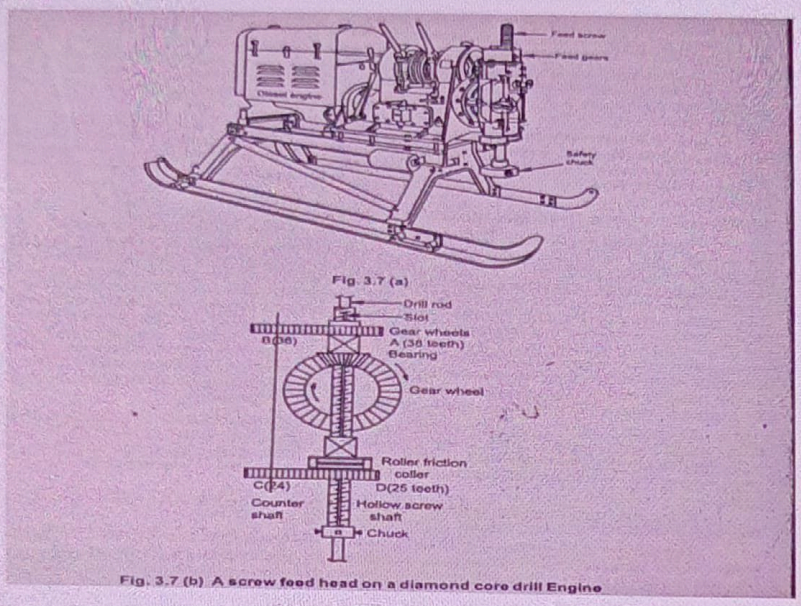
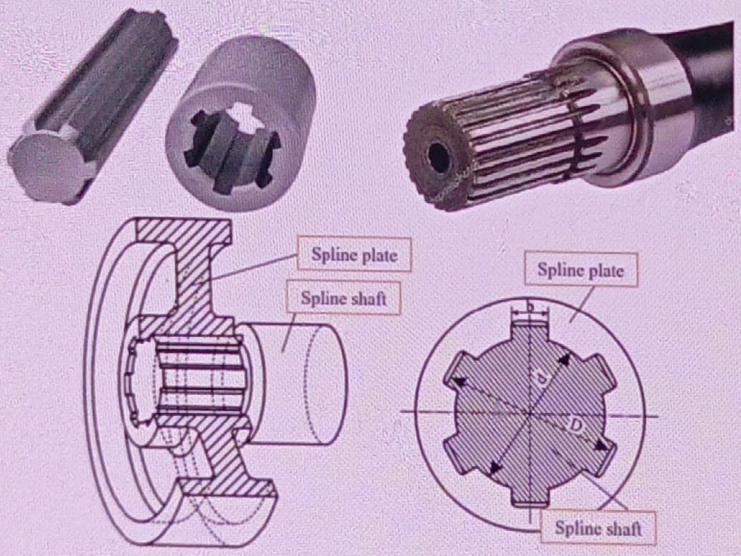


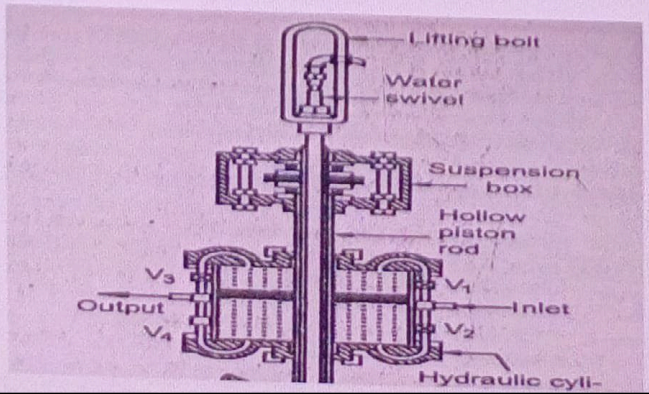
Fig. 3.7 (a)

Fig. 3.7 (b) A screw feed head on a diamond core drill Engine



Hydraulic feed mechanism

- The general principle of a typical hydraulic feed mechanism (excluding the engine and frame) for a deep boring, the main features, starting from the bottom, being the chuck, the bevel driving gears, the hydraulic cylinder and the ball-bearing suspension box.
- At the top is seen a lifting bolt and water-swivel whose functions are self-evident.
- There are three hollow rods, one within the other, namely, the inner bore rod, the middle drive rod and the outer piston rod.
- The inner bore-rod is clamped to the drive-rod by the chuck.
- The drive rod is supported by the collar-plate in the suspension box, the latter is supported by being fixed to the hollow piston rod which carries the piston in the hydraulic cylinder.
- This cylinder is firmly fixed to the engine frame work.
- The rate of feed of the bore-rods is governed by the rate at which the piston descends
- The drive rod is free to rotate within the suspensions box and within the hollows piston rod.
- The drive-rod had on its outer surface ribs or splines which pass through slots or grooves in the box of the horizontal bevel drive-wheel.
- It can thus be rotated by the gear wheels (whose position is fixed) but it is free to descend through the horizontal wheel, carrying with it the and boring tools at their lower end.



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Hydraulic feed mechanism

- The general principle of a typical hydraulic feed mechanism (excluding the engine and frame) for a deep boring, the main features, starting from the bottom, being the chuck, the bevel driving gears, the hydraulic cylinder and the ball-bearing suspension box.
- At the top is seen a lifting bolt and water-swivel whose functions are self-evident.
- There are three hollow rods, one within the other, namely, the inner bore rod, the middle drive rod and the outer piston rod.
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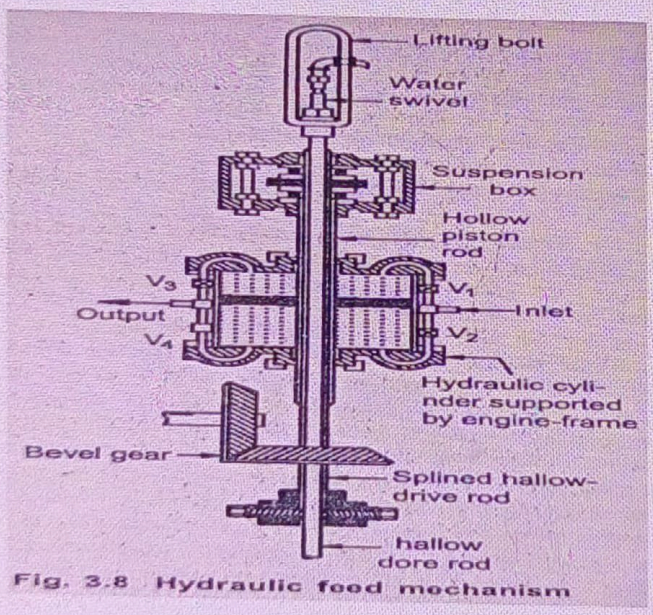

Fig. 3.8 Hydraulic feed mechanism

Core recovery

- To collect the core of the rock drilled, a device known as the core barrel is used.
- It's length varies from 0.5 to 3 m.
- There are two types of this:-
  - The single tube core barrel
  - Double tube core barrel
- A single tube core barrel is suitable for homogeneous formations where the core is not eroded by flushing water and a solid core can be taken without risk of blockage in the barrel.
- The diamond crown or single tube core barrel is also called calyx.

- The core lifter is placed within the bevel shell which has its inside conically shaped to receive the former.
- The core lifter has a split ring.
- It occupies the wider portion of the bevel shell when drilling takes place so that it has little or no tendency to grip the core.
- After certain progress in drilling when the rods are lifted to take out the core, the split ring descends inside the bevel shell and grips the core.
- The latter may now be broken off by a twist and raised to the surface.

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- The latter may now be broken off by a twist and raised to the surface.
- The core is replaced after about 250m of drilling.
- The larger particles of drill cuttings which the circulating water fails to carry upto the surface settle down in the mud bucket. Where supply of flushing water is plentiful. The water under circulation is nearly 900 litres per minute.

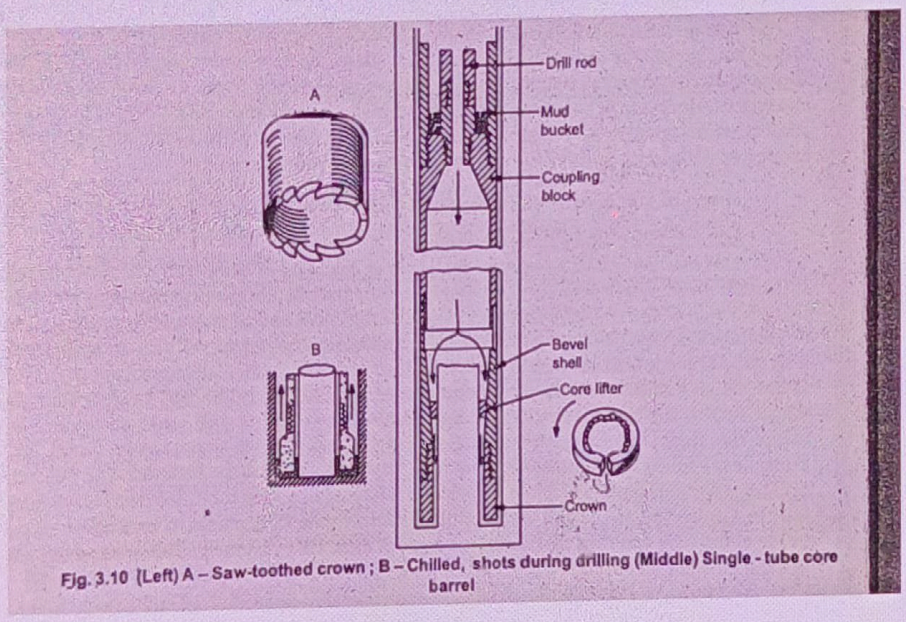

Fig. 3.10 (Left) A – Saw-toothed crown ; B – Chilled, shots during drilling (Middle) Single - tube core barrel

- In soft and friable rocks, the core is partially washed away due to the circulating water flowing past it.
- The rotation of the barrel greatly assists in grinding the core so that its recovery in a single tube core barrel is poor.
- To avoid these difficulties a double tube core barrel is used, specially where good core of soft rock is desired.
- In a double tube core barrel the inner tube which holds the core does not rotate during drilling.
- A double tube core barrel improves drill bit economy and overall drilling performance.
- Core recovery is good in hard uniform rocks, but poor in loose, soft, friable or weathered rocks.
- Vibrations of drill rods result in poor recovery.
- In hard rocks, to achieve good core recovery the drill should be run at low speed and heavy pressure
- In soft rocks, reverse procedure should be adopted.
- The combination of pressure on drill bit and its rotational speed should be such as to give vibration-free drill string during drilling.

Wire Line Drilling

Normally core barrels of 0.5 m to 3 m length are employed.

For removal of core during the conventional method of drilling, all the drill rods have to be withdrawn to the surface, after firing a length equal to length of core barrel.

The withdrawal of the rods and their re-introduction into the borehole with the additional drill rod, after removal of core, takes a considera time, nearly 75 to 90% of the total time spent on drilling.

A wire line drilling technique is an improvement to reduce this time.

The rods are not taken out to remove the core which is collected in the core barrel tube during drilling.

The tube is pulled out the surface through the drill rods with the help of a catcher which is lowered through the rods by a 5 mm dia, wire rop

The catcher grips the tube containing the core.

Core size less than BX is not possible with wire line coring equipment

The speed of drilling with this equipment is nearly 18 m per shift (8 hours) in the types of rocks met with in the coalfields.

All the drill rods need to be withdrawn to the surface only when the bit has to be changed.

Wire line drilling is possible upto a depth of 1000 m.

As stated earlier, the rods used for wire line drilling have specifications as laid down in "Q" series decided by DCDMA.

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it.

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- Wire line drilling is possible upto a depth of 1000 m.
- As stated earlier, the rods used for wire line drilling have specifications as laid down in "Q" series decided by DCDMA.
- An ordinary drilling equipment can be adopted to wire-line drilling and hoisting equipment with suitable modifications.
- Its pressure is used for rotation of drill rods through a hydraulic motor and also for hydraulic feed.
- Its main advantage is that speed can be varied from zero to a certain limit without any fixed ratios that are possible in a geared drive.

Water Loss During Drilling

- When drilling in fractured zone or strata with cavities the circulating water is lost in such zone and fails to appear at the surface. This is known as water loss.
- To seal up the cavities or fractures around the hole, saw dust, husk, etc. are mixed in circulating water.
- If this is ineffective, it may be necessary to ream the bore hole and fix a casing pipe to cover the fractured zone.
- The casing pipe can be removed after completion of drilling.
- At depth, instead of resorting to a casing pipe a special type of mud like bentonite or kaolinite may be used to overcome the water loss
- Drilling mud is a suspension mixture of certain types of colloidal clay in water and/or oil and used as drilling mud.
- The mud most commonly used in diamond drilling is a slurry of clay and water.
- Properly controlled drilling mud slurries can prevent caving or collapse of borehole sides by building thin, impermeable protective coatings of clay particles to the walls of the hole.
- Diamond drilling method is suitable for drilling at any angle to obtain cores of friable Strata as well as the hardest rock
- It has been adopted for drilling upto a depth of 3000 m and hole diameter upto 200 mm. Drilling upto such large depths is not required in coal mining areas where the maximum drilling depth is upto 1000 m, as coal mines are rarely deeper than that
- Other methods of rotary drilling differ from the diamond drilling method essentially in the type of drilliing bit used. The drill bits used are as follows
- The saw-toothed crown
  - The drilling tool is a saw-toothed steel crown or cutter. The teeth are set alternately inward and outward to give the necessary clearance. The speed of rotation is only 5 to 10 r.p.m. and the drill bits are suitable only for drilling through rocks of medium hardness; only holes of diameter not less than 150 mm are possible
- Rock roller bits
  - These are suitable for hole diameter between 75 mm and 300 mm. In mining areas these are commonly used for drilling large diameter holes in mechanised quarries.
  - Flushing of the hole with compressed air instead of by water under pressure is the common practice with this type of bit.
  - Rock roller bits can be used for deep hole drilling with speed and are suitable for mostly vertical downward holes.
- Chilled steel shots
  - These shots are prepared by heating very finely divided steel particles to a very high temperature and then suddenly cooling them in ice cold water
  - Chilled shots are used in with a plain steel shell or cylinder with a diagonal slot near the bottom.
  - They are fed through the hollow drill rods and pass to the bottom of the hole where they get caught between the bottom end of the cutting shell and the rock.
  - As the shell and the drill rods rotate, the chilled steel shots cut the rock by a milling action.
  - The method is suitable for vertical and large diameter holes of 100 mm to 750 mm.
  - It is also called calyx drilling, but is not much favoured these days as diamond drill bits have gained wide popularity and are available in large diameters upto 250 mm.
  - Calyx drilling proved to be a significant step during the development of drilling techniques.
  - Except the rock roller bits, all the other drilling tools used for rotary drilling provide cores of the strata passed through.

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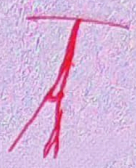
Borehole Deviation.

→ Borehole gets deviated from its original path, horizontally or vertically inclined.

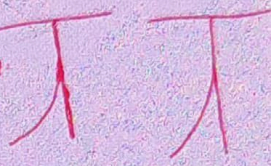
→ Deviation is approx 2° per 30m length.

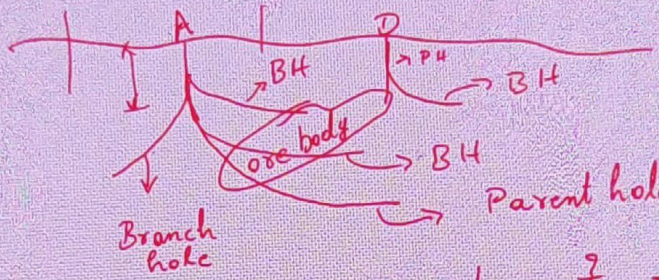
→ Deviation occurs at some angle



→ Measurement of borehole deviation
↳ Borehole survey.

→ Borehole deflection
↓
① Done by driller to control deviation.
② Intentional ~~deflect~~ deviation.

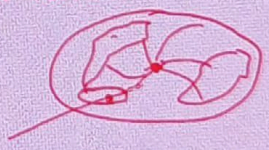




Borehole at D → Deviation के कारण ore body show नहीं करेगा

Parent hole at A → Covers wide area of prospecting
↓ → with the help of Deflected branch holes it covers a more wider area
Circular Area.

Major factors affecting bore hole deviation.
→ depth
→ Angle.
→ Nature of strata drilled



Rules of Borehole deviation.
→ Upto 100m depth deviation is small.
→ Deviation increases with depth.
→ Borehole bending planes को follow करता है।
↓
BP पाया कहाँ जाता है।
↓
① b/w hard & soft rock.
② dykes, fault.

Borehole deviation depends on
① hole dia,
② Bit pressure
③ Core barrel
④ Casing.

ऐसा भी कह सकते हैं कि हम इसे control करेंगे इनकी मदद से।

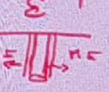
Dia of hole
→ Large dia → less deviation.
→ more deviation.

Dia of hole
→ Large dia → less deviation.
→ Small dia → more deviation.
→ BX size → 2° – 3° per 30m.
→ AV size → get doubled, Ex size – gets tripled

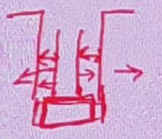
Bit Pressure.
→ High bit Pressure increases deviation.
→ Sharp bit with less bit pressure
↳ less deviation

blunt के मुकाबले कम रहेगा
or
bit जो तेजी से penetrate कर रहा है

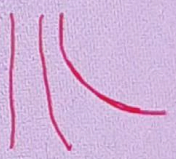
Core barrel
→ Diamond drill hole remains straight.
→ Hole के कारण barrel deviate नहीं करता है।
↳ it depends on → barrel की stiffness.
→ Clearance in hole.



→ किस तरह के barrel use करें?
① heavy walled barrel.
② barrel or hole side के बीच में gap कम हो।
↓
This will reduce deviation.



→ Deviation is more
↳ worn core barrels
↳ light bore rods.



How to control borehole deviation.
① Suitable hole dia, bit pressure, core barrel. Casing.
② Use full dia drill rods for entire length.
③ Use proper couplings with good threads.
④ By deflection method.

Borehole Survey
→ Measurement of deviation

Borehole Survey

→ Measurement of deviation

→ Borehole survey करने का उद्देश्य (to find out)

① Direction of borehole.

② Points पता करने के लिए जहां से deviate हुआ है।

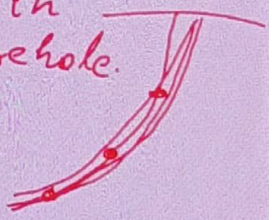
③ With this 3D information at different angles can be determined

Methods of borehole survey used to find out.

① Some methods find deviation angles only.

② Angle + bearing deviation at some points only.

③ Some instruments measure both continuously all along the borehole.



Methods of Borehole Survey

→ Etch method → Hydrofluoric acid

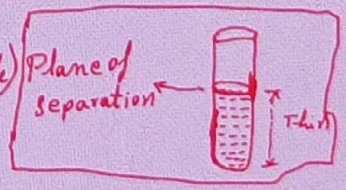
① Measure deviation → angle only.

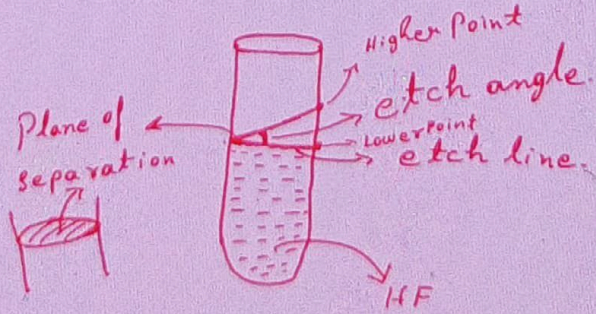
② HF acid corrodes glass.

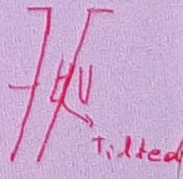
→ HF solution glass test tube को thin करता है।

→ Plane of separation को empty test tube से compare किया जाता है।

→ Tilted test tube will give (etch angle) and till angle can be found







HF Solution

Tilted

→ Diamond drills में dilute HF को test tube में डालकर drill hole में डाला जाता है। थोड़े समय बाद etch line बना देती है tube में। etch angle measure कर लिया जाता है।

→ HF Conc^n → 5%, 8%, 10%
↳ by distilled water it can be obtained.

→ Suitable for AX, BX & NX size of hole

→ 50 ml acid को पहले mix किया जाता है। इसके बाद Test tube में डालकर फिर brass/mild steel के container में डालकर नीचे किया जाता है।

→ Inclination Readings → at every 50-60 m.

→ Four containers are lowered at same time.

⇒ In shorter drill holes
↳ 10% acid
↳ 40-45 minutes → etch line

⇒ Withdraw करने के बाद etch tube को तुरंत empty करके wash किया जाता है।

→ Line of etch → higher & lower Points are marked.

→ Oldest method of borehole survey

other instruments for measurement of deviation

1. Carlson Compass
2. Tropari instrument
3. Borehole camera.

Disadvantages of Borehole camera

→ expensive (1)

→ Require facility to process film.

→ equiped with small magnetic compass needle
↳ gets affected by rod.

Directional Drilling.

→ To control direction of borehole.

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Directional Drilling.

→ To control direction of borehole. (course)

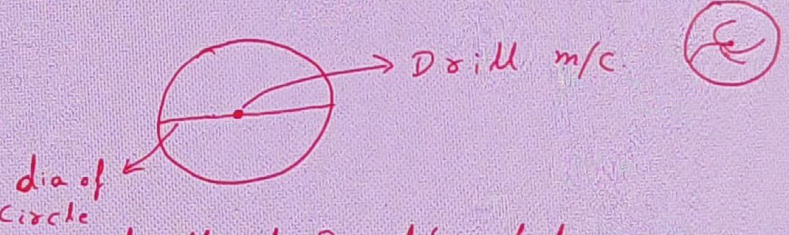
→ To follow a pre-determined path.

→ To complete borehole at desired point.

Main objectives of directional drilling.

1. To control deviation
2. To make holes correct into normal course
3. To remove lost tools, broken bits etc.
4. To change drill hole direction & to maintain different zones.
5. Parent hole से branch hole निकालने के लिए।

Range of directional drilling.

1. Limited to a circle.
2. 

→ depth of Parent borehole.

Deflection of boreholes

Methods used for deflection of boreholes.

1. Casing deflection
2. Use of wedges.
3. Sonic orienting assembly
4. Arc cutting

→ Natural deviation के direction में deflection करने से अच्छे Results मिलते हैं।
↳ इसके Against deflection inconvenient & ineffective होता है।

→ Branch holes के कारण surface से Prospecting के लिए boreholes नहीं करने पड़ते हैं।

→ Deep oil wells holes में Deflection technique use होता है।

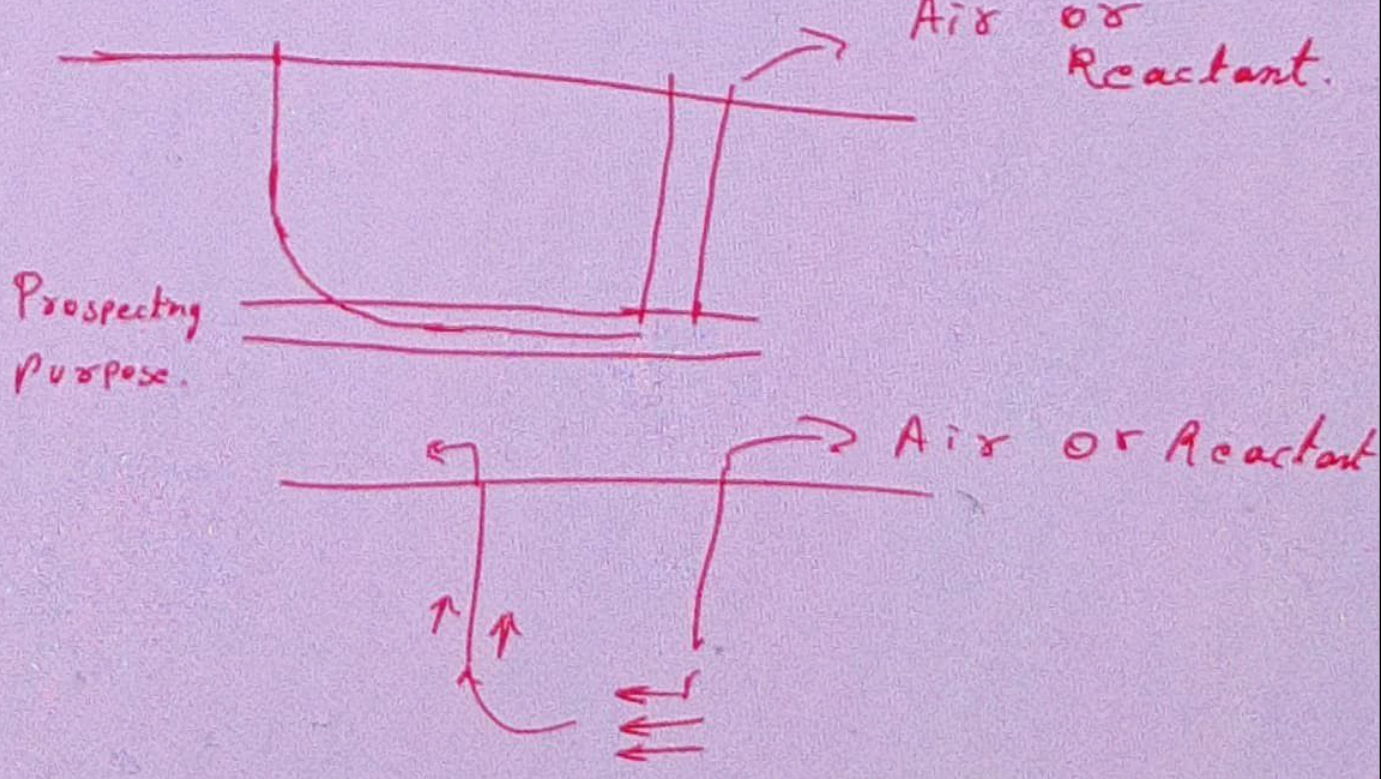
→ In India is not used.

→ U/g gassification में surface से at least

→ In India it is not used.

→ U/g gassification में surface से at least 2 boreholes की जरूरत पड़ती है।

↳ एक होल में Air or Reactant को डाला जाता है।



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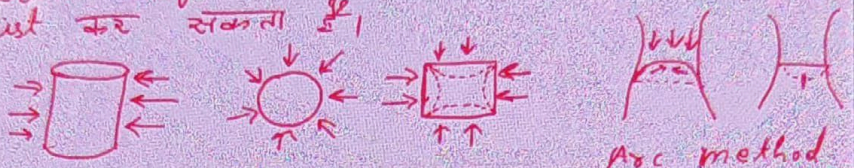
Shaft Sinking

shape & size of shaft

→ Shaft generally circular shape में होता है। Rectangular shape बहुत Rare है।

→ Circular shaft side pressure को अच्छे से Resist कर सकता है।



→ It is easy to sink.

→ Ventilating air का friction कम रहता है।

→ Dia of shaft → 4.8m to 6.7m

→ Rectangular shaft in India

↓

Mochia Magra Mines, Zawar Rajasthan (HCL)

(5.2m × 3.8m), depth → 321m.

30 cm thick concrete lining

→ It is costly operation

↓

50K – 75K per metre.

↓

It includes → Sinking, lining with concrete, head gear, winding engine, Concrete.

→ Drum winding is used in shaft sinking.

→ friction winding is used for deep shaft.

→ Shaft site select करने के लिए Pilot holes drill किए जाते हैं।

↓

To have core of the rocks.

→ Pilot hole shaft का centre नहीं माना जाता है। but shaft के Radius के 50m के अंदर रहता है।

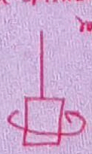
→ Details given by Pilot holes.

1. Confirmation of shaft site
2. Selection of water control methods.
3. estimation of sinking time & cost.
4. Design of shaft & Permanent lining.

Core dia → 10mm

Surface plant & equipments

1. Steam boilers / diesel engine or electric power for winding engine, pump etc.
2. Winding engine → Locked coil ropes → Non-Spinning rope
3. Steel headgear → Temporary
4. Double drum winch for walling, scaffold lighting cables, shot firing cables, pump suspension ropes, pump cables.



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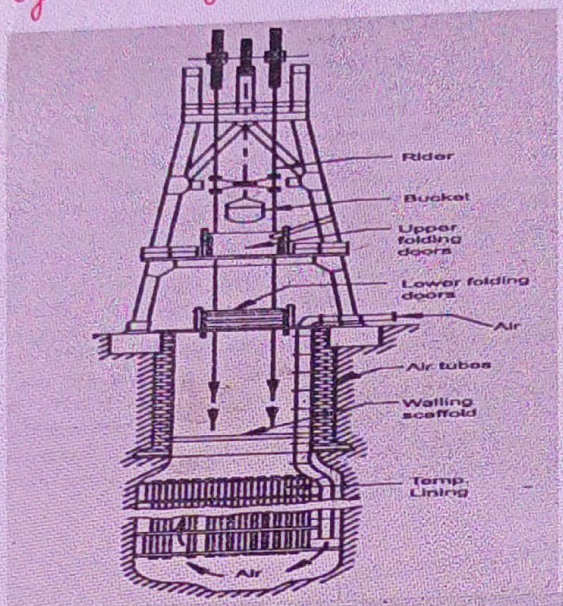
ropes, Pump cables.

(5) Air compressor for Jack hammer drills or other equipments.

(6) Fan of nearly 300m³ per minute capacity.



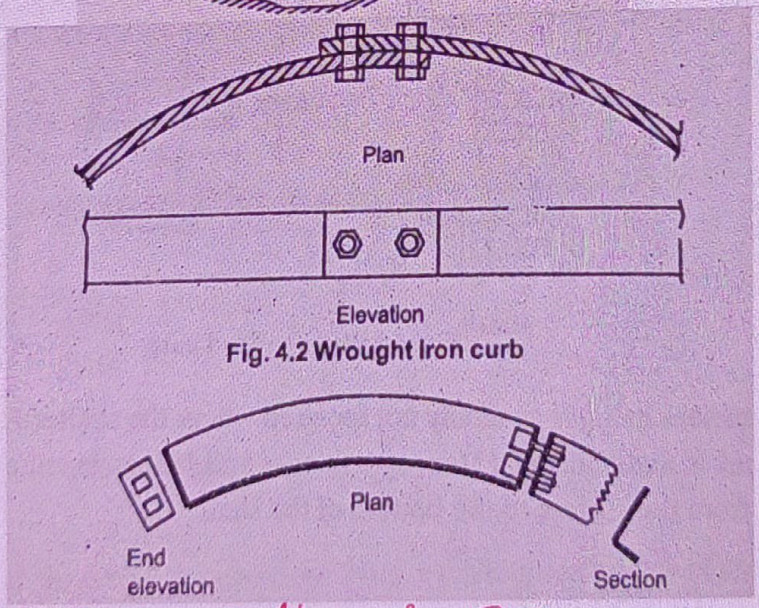


Fig. 4.2 Wrought Iron curb

⇒ Generator → Lighting के लिए
↓
diesel/steam engine.

→ Folding doors to cover shaft top

→ Shaft Centering arrangement

→ Signalling arrangement
↓
pit bottom to pit top → winding engine room

→ chutes, buckets & tipping Tubs with tramline
↓
debris हटाने के लिए।

→ Workshop.

German type air lock system

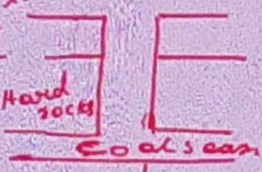
Lamp room, first aid room, magazine, stores, offices

→ shaft का centre concrete pillars से mark किया जाता है।
↓
एक plate होती है जिसमें centre

Lamp room, first aid room, magazine, stores, office

→ shaft का centre concrete pillars से mark किया जाता है।
↓
सभी में एक plate होती है जिसमें centre line mark होता है।

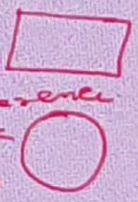
→ Shaft Sinking strata



① Sub soil or alluvium.
② Hard rocks → below alluvium & above mineral bed
sand stone, shale, thin coal seams.
③ Coal seam or mineral bed.

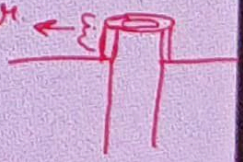
Perimeter of excavation

→ Pegs से mark किया जाता है।
↳ लकड़ी का खूटा



→ Radius ⇒ finished radius + thickness of lining + Clearance of 230-300

→ Collar / shaft collar
↳ starting point of vertical shaft at surface.



→ In sub soil / Alluvium → upto 3m to 20m
↓
excavated by Chisel & hammer / Cutting picks.
blasting नहीं करते है।

→ excavated material को buckets से hoist करके निकाला जाता है। Manila rope की मदद से।
↓
Crane → for upto 30m depth.

→ Sinking के समय shaft के sides को vertical और circular रखा जाता है।
↓
by radius rod → plumb bob wire की help से radius measure करते है।
↓
Surface से shaft के centre में लटका रहता है।

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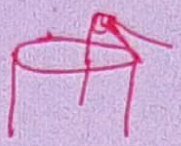
Temporary Lining

→ To prevent collapse of shaft sides.

→ a heavy frame of wood or steel at shaft के top पर बनाया जाता है।

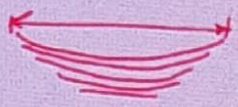
→ इससे temporary lining कि topmost ring को suspend किया जाता है।

→ Iron spikes की मदद से भी temporary lining को suspend किया जाता है।



→ temporary lining consist of
- ↳ skeleton rings (curb)
- ↳ hangers
- ↳ Planks of sal wood
- ↳ tightening wedges.

Skeleton rings.



- ↳ mild steel से बना होता है।
- ↳ 3m के segments में होता है।
- ↳ shaft के circumference के shape में होता है।
- ↳ width — 100mm, thickness — 25mm
- ↳ joined by fish plate or overlap joints.
- ↳ assembling surface पर ही होती है।

Wooden planks.
- ↳ length — 2m, width — 215mm, thickness — 38mm.
- ↳ wedges को Rings और planks के बीच में लगा कर tight कर दिया जाता है।

→ हर 5वें Ring को ऊपर वाली Ring से iron hanger से suspend किया जाता है।

→ hanger → Dia → 25mm

→ Interval b/w 2 hangers — 1.2m.

→ Every 4th or 5th ring को Plugs की help से support दिया जाएगा।
- ↳ shaft sides में hole करके।

→ Friction planks को अपनी जगह पर रखता है

→ Cavities behind planks filled with wood.

→ Blasting should be avoided in the area where temporary lining is necessary

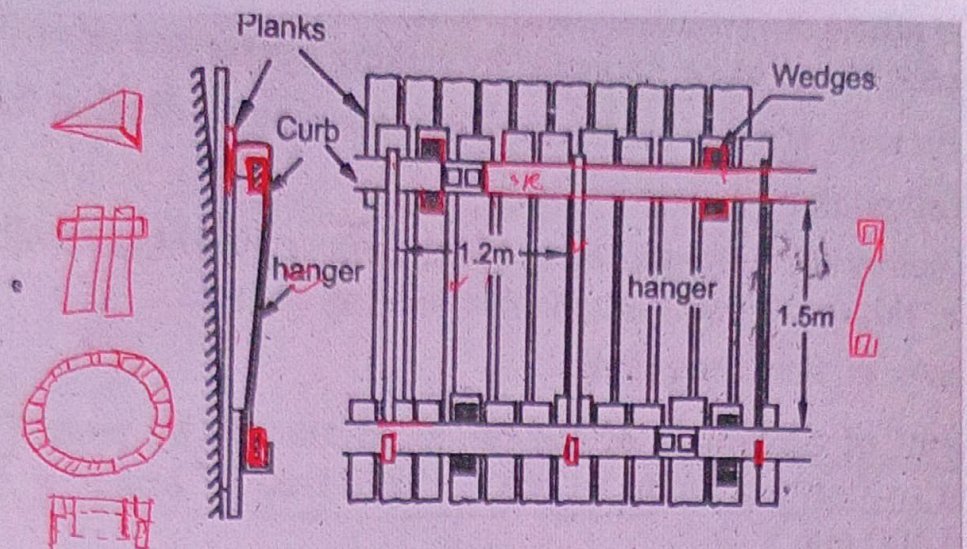
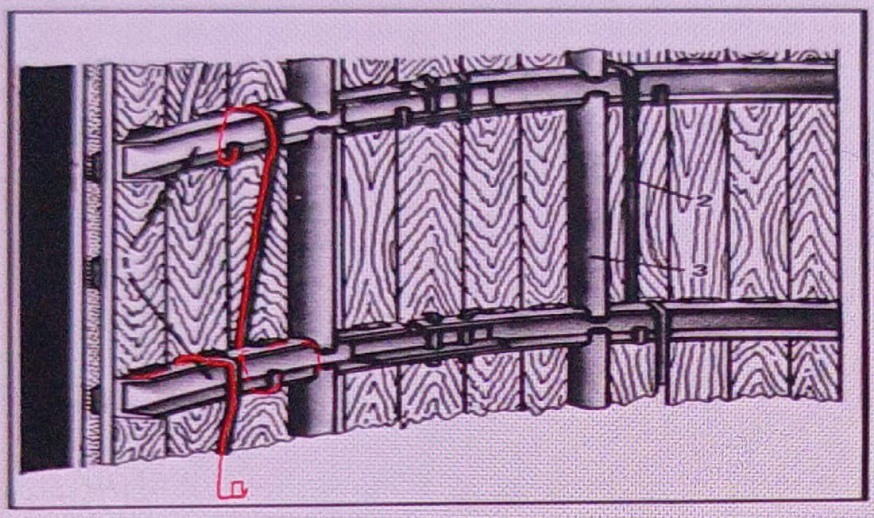


Fig. 4.5 Temporary Lining



Permanent Lining.

→ strong rock ~~मिलने~~ पर shaft dia is limited to finished dia.

↳ 3-4m कि depth तक यही किया जाता है।

→ इसके बाद PL के लिए arrangement किए जाते हैं

① brick
② Concrete
③ Steel tubbing.

→ Brick walling → ordinarily compact or moderately wet strata में use किया जाता है।

first class bricks → well burnt.

↓

225mm length, 115mm breadth, 75mm height

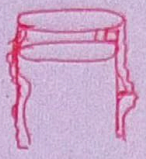
→ Thincknes of brick lining → 0.4m to 0.6m.

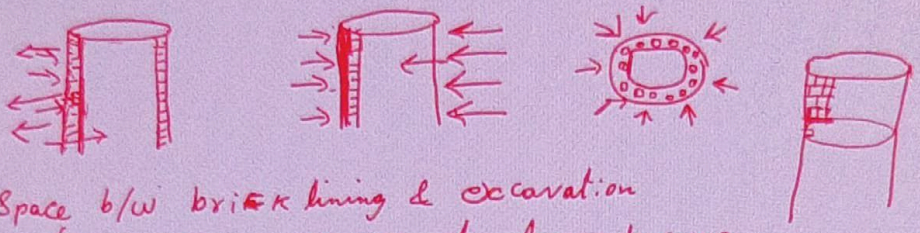
→ Walling के समय sinking usually रोक दिया जाता है

→ 150mm thickness की concrete lining की जाती है।

इसके बाद cast iron का bricking curb लगाया

→ Thickness of brick lining →
→ Walling के समय sinking usually रोक दिया जाता है
→ 150mm thickness की concrete lining की जाती है।
→ इसके बाद cast iron का bricking curb लगाया जाता है।
→ bolting किया जाता है और joints में wedges की help से support किया जाता है।
→ Curb के ऊपर brick walling किया जाता है

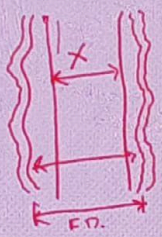




→ Space b/w brick lining & excavation
↓
filled with → ash, sand, loose bricks.
or
Packed with

→ Packing hydrostatic pressure को reduce करने में help करता है।
→ Curb level पर weep holes छोड़ दिए जाते हैं।
→ weep holes का पानी water garland में collect होता है।

→ water garland से water को pipes की help से shaft में नीचे लाया जाता है।
→ water garland also called garland curb.
→ Drain pipe dia → 50mm.



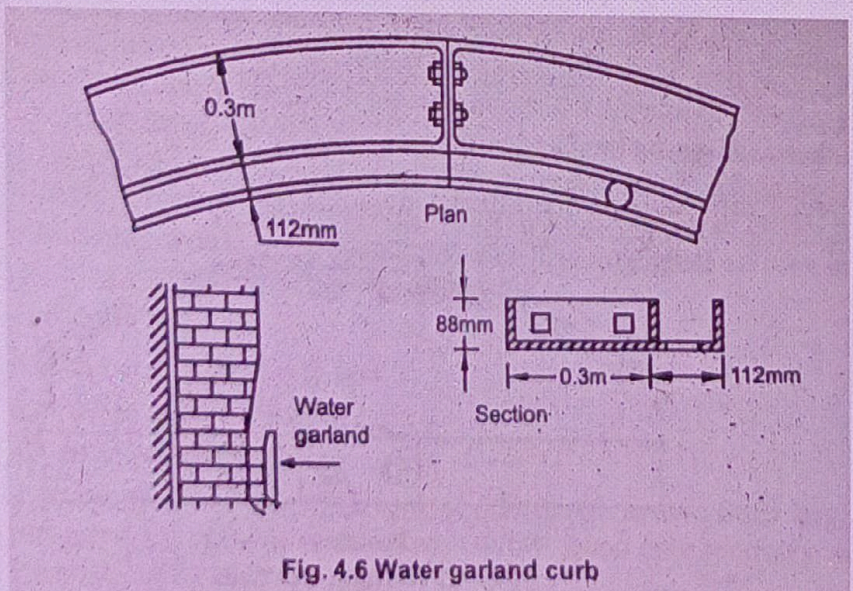
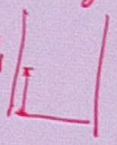


Fig. 4.6 Water garland curb

Walling Scaffold

→ Brick wall का construction walling scaffold or platform से किया जाता है।
→ यह एक sal wood का Frame है।
→ 0.3m × 0.3m square members sal planks.
→ It has an opening at the centre 2m × 2m for passage of sinking bucket.
→ Scaffold को 2 ropes की help से suspend किया जाता है।
→ Double drum winch से Raise / lower किया जाता है।
→ Scaffold dia is less than finished dia

→ 4 sliding bolts to keep the platform steady.
→ from one position of scaffold 1.3m of walling can be done.
→ Shaft sides में 9m से 16m के intervals में buntons लगाए जाते है।



↳ To support cables, delivery pipes, compressed air

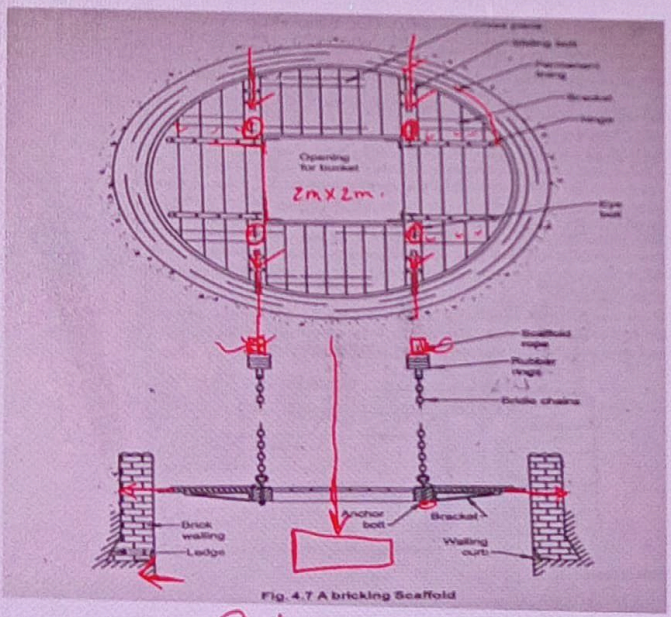
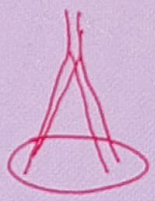
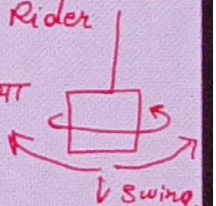


Fig. 4.7 A bricking Scaffold

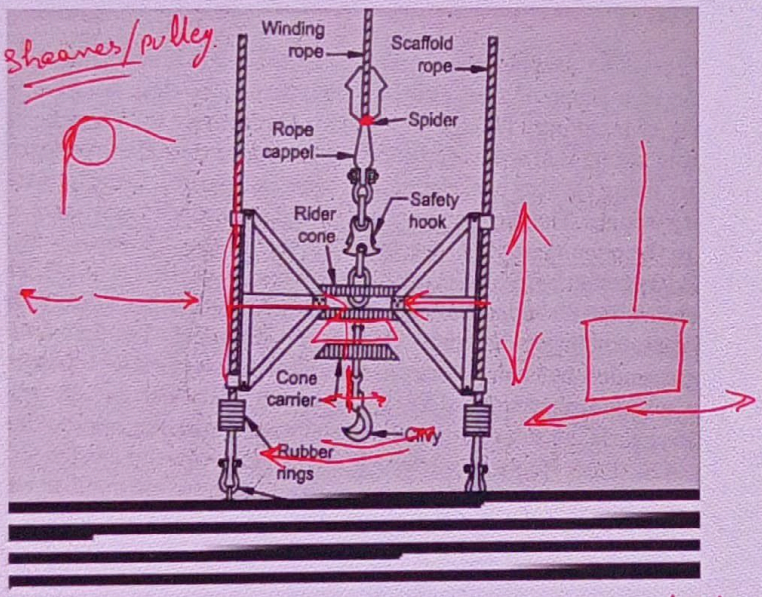


Rider

→ Guide ropes are not used during shaft sinking.
→ Bucket की swing को रोकने के लिए Rider use किया जाता है।
→ Locked soil का भी इसके साथ use किया जाता है।
→ It is Cone shaped.
→ Walling scaffold को support करने वाले Ropes



→ It is Cone Shaped.
→ Walling scaffold को support करने वाले Ropes में लगा होता है।
→ जब Bucket को Walling scaffold से भी ज्यादा नीचे भेजा जाता है तब Rider scaffold Ropes के Capel पर रुक जाता है और bucket का Rope rider Cone से होते हुए गुजरता है।
→ Spider → Sheaves को कहा जाता है जो rope को guide करते है।
↳ Overwind को prevent करता है।
→ With the help of Rider bucket can be raised or lowered at greater speed.



Drilling & Blasting in sinking shaft.
→ Thumb rule → No. of holes in a ring = 3 times dia of shaft in m.
→ Holes को hand held jack hammer से drill किया जाता है।
↓
Operated by Compressed air
↓
air pressure → 6 Kgf/cm²
→ Compressed air को Rubber hose pipes से supply किया जाता है।
↓
Pipe dia → 100mm.
→ अगर shaft का dia 6m है तो 2 से 3 बार drill करने में 3m³ per minute free air consume होता है।

→ अगर shaft का dia 6m है तो 2 से 3 बार drill करने पर $3m^3$ per minute free air consume होता है।

→ Hole dia → 38mm.

→ Hole depth → 1.2m to 1.5m.

→ Drilling के बाद wooden plugs से hole को cover कर दिया जाता है।

→ Gelatinous high explosives use किए जाते हैं।
↳ Sand stone में Ajax G

→ Special gelatine in hard rock.

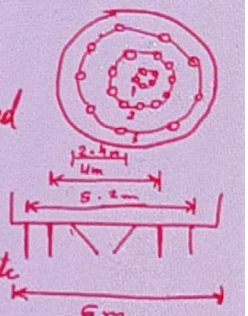
→ A hole 1.2m to 1.5m deep → 0.6 to 0.9 kg explosive.

→ Low tension detonators used.

→ water holes में stemming का काम करता है।
↓
for more effective blasting drill chips can be used.

→ Inner ring के holes को पहले blast किया जाएगा।

→ एक Ring के shots series में connected होते हैं।



→ Before blasting
↳ Remove or raise equipments, lights etc
↳ Withdraw all men.
↳ Close folding doors.

→ Blasting by hand operated heavy duty exploder at surface.

→ Inner Rings → Sumper Rings.

→ After sumper ring is blasted debris को clear करके outer ring को blast किया जाता है।

→ Advance in 1 blast → 1.2m for 1.5m deep holes.

Clearing Up debris.

→ bucket to remove debris → Kibble, bowk or hoppit.

→ bucket को detaching hook से attach किया जाता है। by bridle chain or clevy.

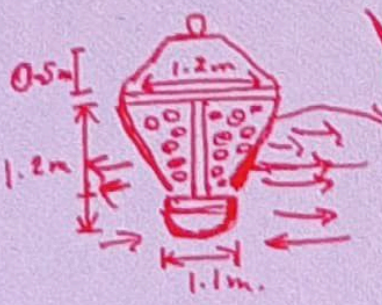
→ Two buckets are used

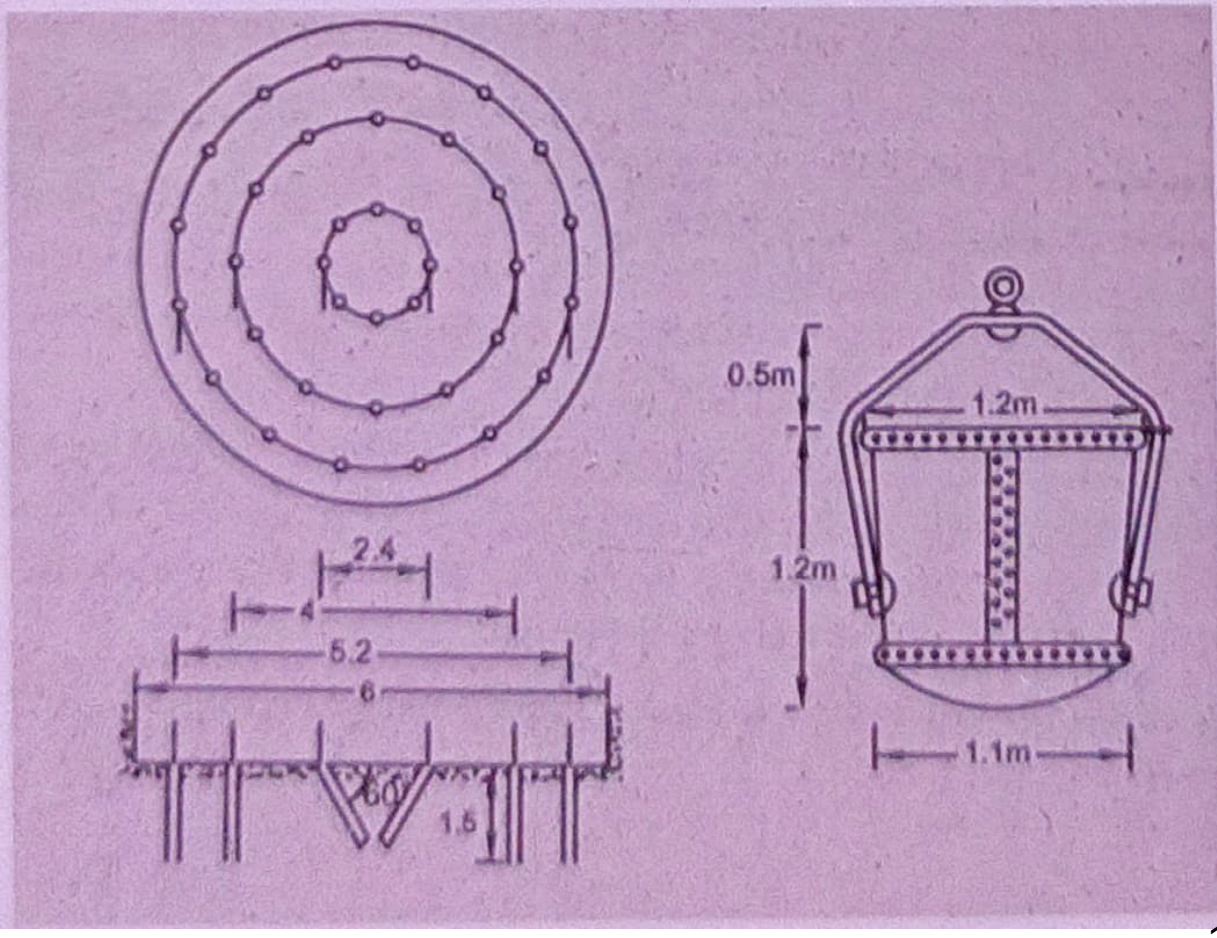
→ Chutes or V doors का use किया जाता है ताकि bucket tilt हो जाए forks को रखने में।

holes.

Clearing up debris.

→ bucket to remove debris → Kibble, bowk or hoppit.
→ bucket को detaching hook से attach किया जाता है। by bridle chain or clevy.
→ Two buckets are used
→ Chutes or V doors का use किया जाता है ताकि bucket tilt हो जाए forks को रखने पर।





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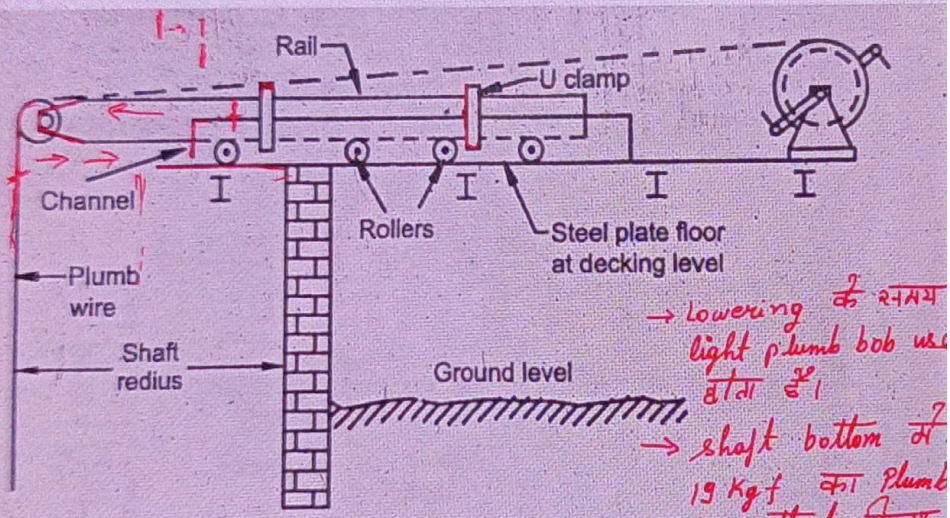
Shaft Centering Arrangement

→ Shaft की verticality and radius को Day में एक बार check किया जाता है।
→ Plumb wire को surface से shaft में suspend कर दिया जाता है।
→ Light section rails roller के ऊपर slide करते है।
→ U Clamps rail को overturning or lateral movement से रोकता है।
→ Rail के एक end में Pulley लगा होता है।
→ जब Pulley का Groove shaft के Centre में आता है।
↳ तब Rail और Channel पर 2 points marked होते है वह coincide कर जाते है।



→ lowering के समय light plumb bob use होता है।
→ shaft bottom में 19 Kgf का Plumb bob attach किया जाता है।

Dealing With Water.

→ जब shaft में 100 lit. से ज्यादा water बहने लगता है। तो Pump use किए जाते है।
→ Centrifugal pumps are used for dewatering
→ 2 small pumps are used when some permanent lining is completed.
→ Maximum 8 stages वाला pump use होता है।
→ Sinking के time 1 या 2 stages ही utilise होते है।

Ventilation.

→ 300m³/minute capacity वाला forcing fan use होता है।
→ Air tubes → 0.6m dia
→ bottom made of Canvas.

Lighting

→ Cap lamp → workers
→ each bulb 100W & 110V at shaft bottom

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Lighting

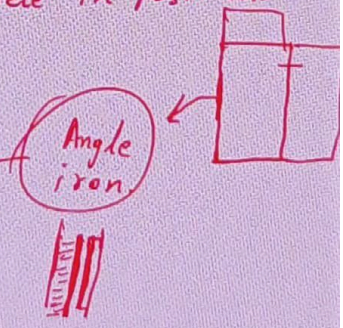
→ Cap lamp → workers.
→ each bulb 100W & 110V at shaft bottom
↓
4 to 6 bulb.

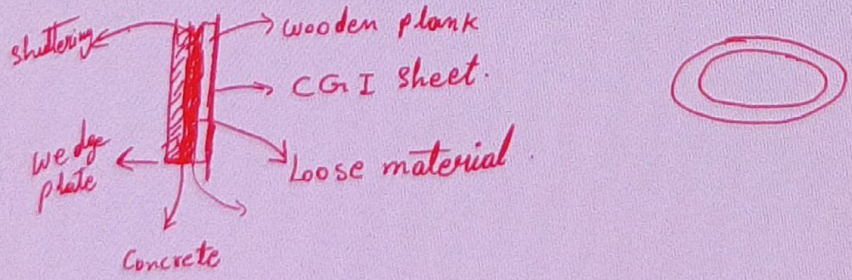
Permanent Concrete Lining

It is of Two types
→ Reinforced concrete lining
→ Monolithic concrete lining

→ Reinforced Concrete Lining.
↳ It is costly
↳ To resist high water pressure.
↳ stronger than brick walling.
↳ less friction to air current.
↳ Can be erected rapidly
↳ its rigidity may crack or collapse with slight earth movements.

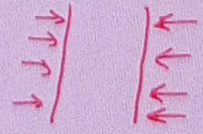
Monolithic Concrete lining.
→ Cement : sand : Coarse aggregate } dry shaft.
1 : 2 : 4
→ hard rock is dressed before lining.
→ Shuttering → To keep wet concrete in position.
↓
1m high steel sheet.
→ CGI sheets.
↳ water percolation for bolting.
↓ is more.
40mm thick.





Cast Iron Tubbing.

→ Cast iron lining known as Tubbing.
→ It is a permanent water tight lining.
→ ① English type tubbing
② German type tubbing



→ Tubbing plate is strengthened with

Construction of German tubbing upwards.

→ Strong level ground prepare किया जाता है।
→ इसके cast iron wedging curb रखा जाता है।
→ Tubbing plates को इसके ऊपर रखा जाता है।
→ one at a time by winding rope.
→ plate is bolted to wedging curb.
→ एक Ring complete होने पर centre line से check किया जाता है। और adjust करके shaft circumference से Match किया जाता है।
→ flanges के बीच के gap में lead sheeting करके bolt से flanges को tight कर दिया जाता है।

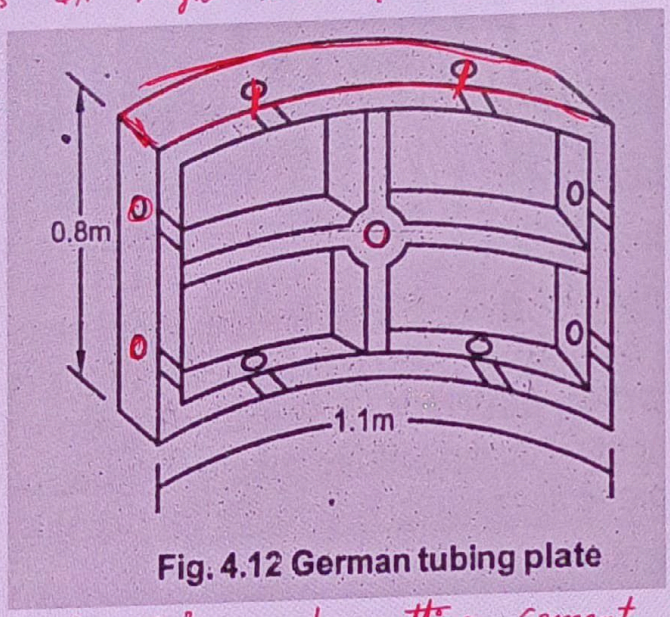


Fig. 4.12 German tubing plate

→ Tubbing के पीछे quick setting cement डाल दिया जाता है। इसके बाद next ring लगाई जाती है।
→ 20m के intervals पर extra curb लगाए जाते हैं।
↓
It depends on nature of strata.

Construction of Germen tubbing downwards.

→ इसमें Construction का काम top से होता है।
→ also called underhung tubbing
→ Inverted wedging curb or Anchorage ring लगाया जाता है।
↳ Tubbing को suspend करते हैं।
→ shaft bottom से 1.5m to 1.8m की distance constantly maintain किया जाता है।

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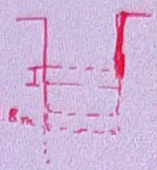
Tubbing को suspend

→ Shaft bottom से 1.5m to 1.8m की distance constantly maintain किया जाता है।

→ हर Plate के centre में एक Hole है ताकि Cement और Concrete को इसके पीछे डाल सकें।



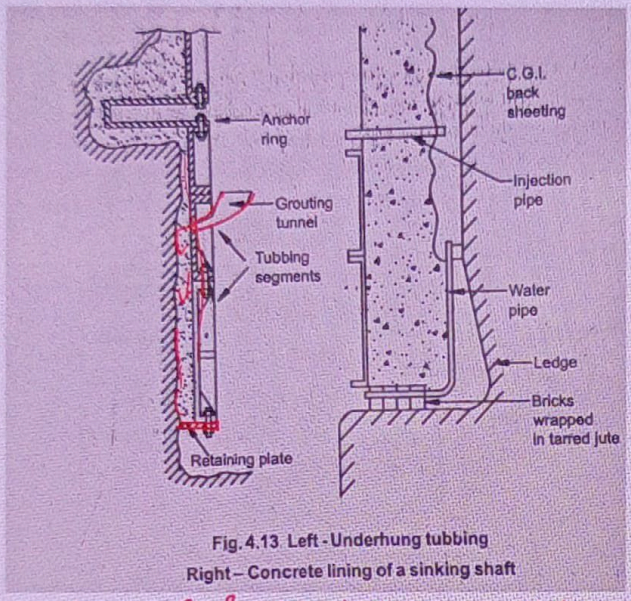


Fig. 4.13 Left - Underhung tubbing
Right – Concrete lining of a sinking shaft

→ Tubbing के नीचे Retaining plate लगी होती है।

→ Concrete set होने के बाद एक drill मारा जाता है ताकि hole को clean किया जा सके

↓
same hole से next round की Rings की back से filling की जाती है।

Advantages of Underhung tubbing

→ No temporary support required
→ No scaffold required.
→ Simultaneous sinking & strata support.
→ Feeders met during sinking can be sealed promptly.
→ It reduces pumping cost.
→ After every 12 to 15m tubbing thickness is increased.

Upward drivage of shaft.

→ Metal mines में specially upward drivage of shaft

Upward drivage of shaft.

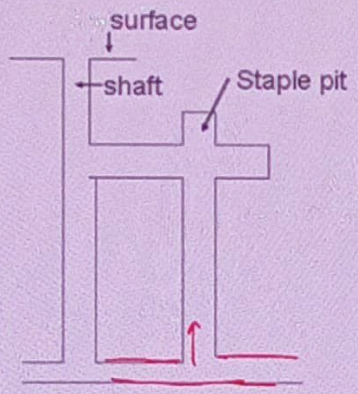
→ Metal mines में specially upward drivage of shaft किया जाता है।

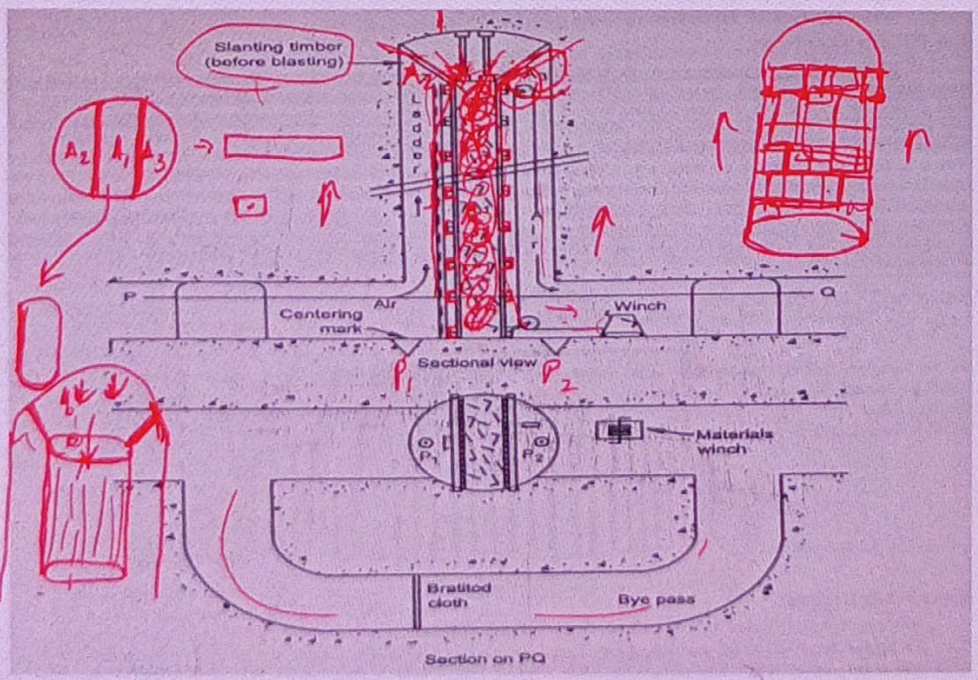
→ 15m की distance तक तो Normally कर लिया जाता है।

→ Staple pit → A vertical shaft which joins two underground roadways but does not extend upto the surface is known as staple pit.

Staple Pit

- Also called blind pit(shaft)
- It is a vertical pit from one under ground working place or road to another under ground working place or road, but does not extend to the surface





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Special methods of sinking

① Pilling system.

→ इस method को piling or sheet piling के नाम से भी जाना जाता है।

→ best for → loose deposits → sand, mud, alluvium.

↳ for upto a depth of 20m.

→ 6m से 10m के लंबाई वाले pile होते हैं

↳ joined by interlock.

↳ ये water tight होता है।

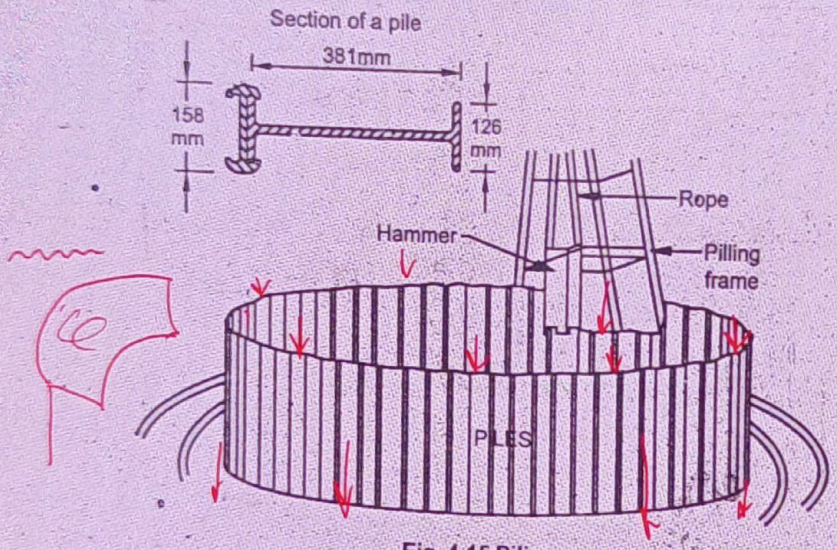


Fig. 4.15 Piling

→ Surface पर piles की Ring बना ली जाती है।

→ Steam pilling hammer से strike करके इसे loose ground में डाला जाता है।

→ ~~इस~~

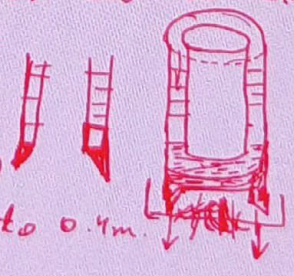
Caisson method.

① Sinking drum Process or open caisson meth

→ brick का cylinder होता है

↳ इस end में m.s ring लगी होती है।

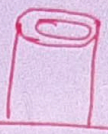
→ Thickness → 0.3m to 0.4m.



→ shaft को excavate करने पर अपने आप धसता चला जाता है।

→ Concrete sinking drums का भी use होता है

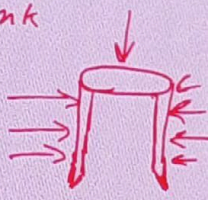
→ Brick वाले में 13 mm की thickness के वाली steel plates.
↳ tensile stress को resist करने में help करता है।



(2) Forced drop method.

→ जहाँ tough & loose ground होता है,

→ Skin friction के कारण shaft sink नहीं होता है।
↓
hydraulic rams से force लगाया जाता है।



→ upto 60 m depth.

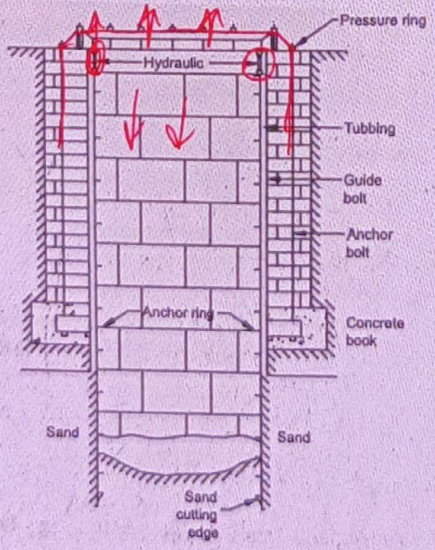


Fig. 4.16 Forced drop shaft

(3) Pneumatic caisson method

→ where danger of ground filling the sha
↳ huge inrush of water.

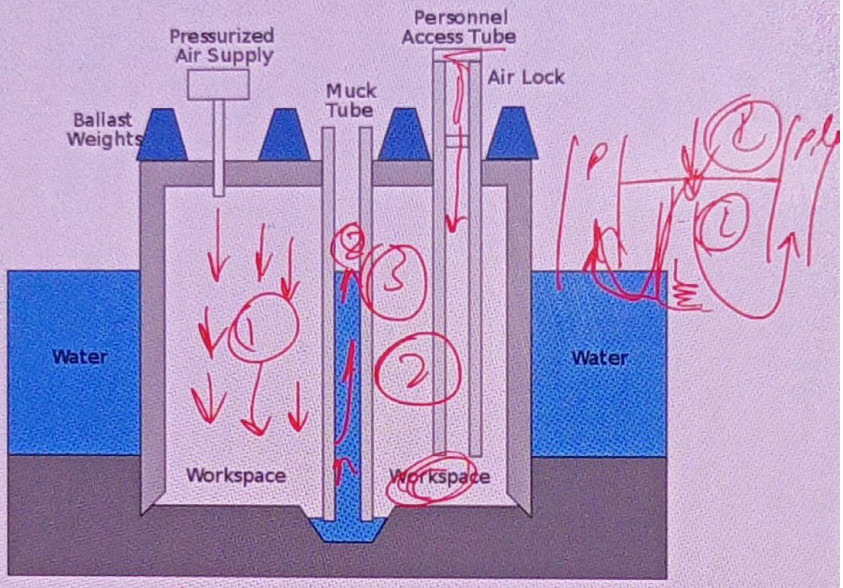
→ Chambers को form करके Compressed air से force लगाया जाता है।

→ Chambers को form करके Compressed air से force लगाया जाता है।

→ Air lock at the top for passage of men.

→ Pressure → 4 Kgf / cm²

→ depth → 30 m.



Freezing method

→ heavy water inrush, unstable friable ground.

→ water bearing strata को large block में frozen ground में convert कर देते हैं।

→ 3 operation

① 1st operation

drill holes → 150 mm dia → at interval of 2.2 mt 3m around shaft.

→ special tubes की lining की जाती है।

2nd operation

→ holes में cold brine sol.ⁿ ($CaCl_2$) को circulate किया जाता है।

→ इससे ice की एक thick wall surrounding strata में create हो जाती है।

3rd operation

→ Thawing → removing ice wall by hot brin

Cementation Process

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Cementation Process

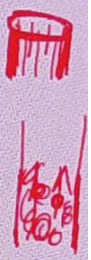
→ In all types of strata

→ objectives → ① To stabilise collapsing ground.
✓ ② To reduce inflow of ground water.
✓ ③ To avoid flooding
✓ ④ To prevent sand boiling

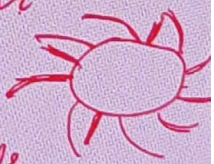
2 phase operation. होता है,
↳ before sinking & after lining.

→ Treatment of cement depends on Ground condition.

① Pre-sinking treatment.
↳ reduces water inflow.
↳ enhances rate of sinking



Post cementation treatment



Pre-Silicatisation Process.

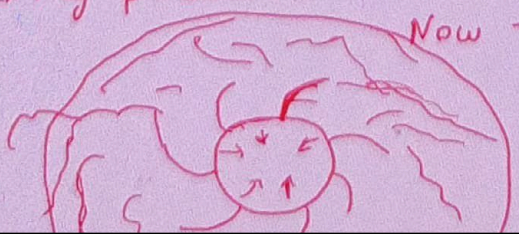
→ इस process में cement और rock के बीच के friction को reduce कर सकते,

→ Silicate soda
→ Aluminium sulphate.

→ holes to be treated with chemical are called Product holes.

→ दूसरे method में holes drill करके cement & water का slurry डाला जाता है,

→ Injecting pressure → earlier → 6 kgf/cm²
Now → 300 Kgf/cm²



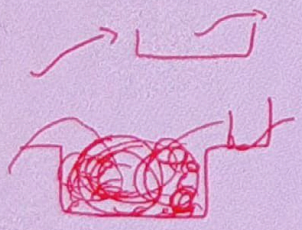
Opencast Mining

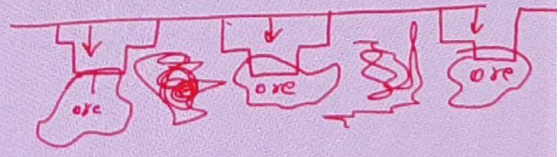
→ Manual Quarrying
- Manual labours employed.
- Small drill m/c are used
- Depth of drill holes → 1.2m – 1.8m.
- Explosives used → Gun Powder/other explosive
- OB & mineral are manually loaded.

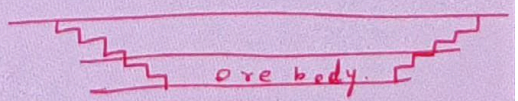
→ Mechanised O/C working.
- Machineries Used → Draglines, Power shovels, Haulpack well-hole drills.
- Depth of drill holes → 6m to 18m.
- Dia of holes → 125mm to 250mm.
- Explosives Used → Liquid Oxygen, gelatine, high explos

→ Placer Mining → In this method mining & washing of unconsolidated and semi-consolidated rock near the ground surface.
eg → Coastal area.

→ Glory hole Mining → In this method mineral is excavated in small pits but is transported to the surface through U/g excavations & transport syste







Mechanised O/C Mining methods.
→ Shovel – dumper Combination
→ Shovel – dumper combination with dragline
→ Inpit Crushing & conveyor technology
→ Surface miner
→ BWE
→ Highwall mining

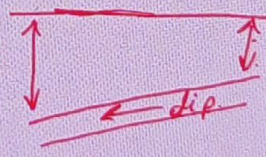
→ Inpit Crushing & conveyor technology
→ Surface miner
→ BWE
→ Highwall mining

Ideal Conditions for O/C mining

→ Thickness of coal seams → greater than 5m
→ Flat gradient → more than 1 in 6
→ Strike length → more than 1 km.
→ Coal में stone bands के होना चाहिए
→ No. of seams → Less is better, with higher thickness.
→ Free from surface structures/features.
→ Preferably non-forest land
→ ∧
→ Availability of adequate place for dumping
→ Stripping ratio depending on quality of coal.

Quarriable limit.

→ OB की thickness बढ़ने पर quarry operations का Cost बढ़ जाता है।
→ Economic working limit of Quarrying.
i.e. quarriable limit depends on
① stripping ratio
② thickess of OB
③ thickness of mineral deposit.

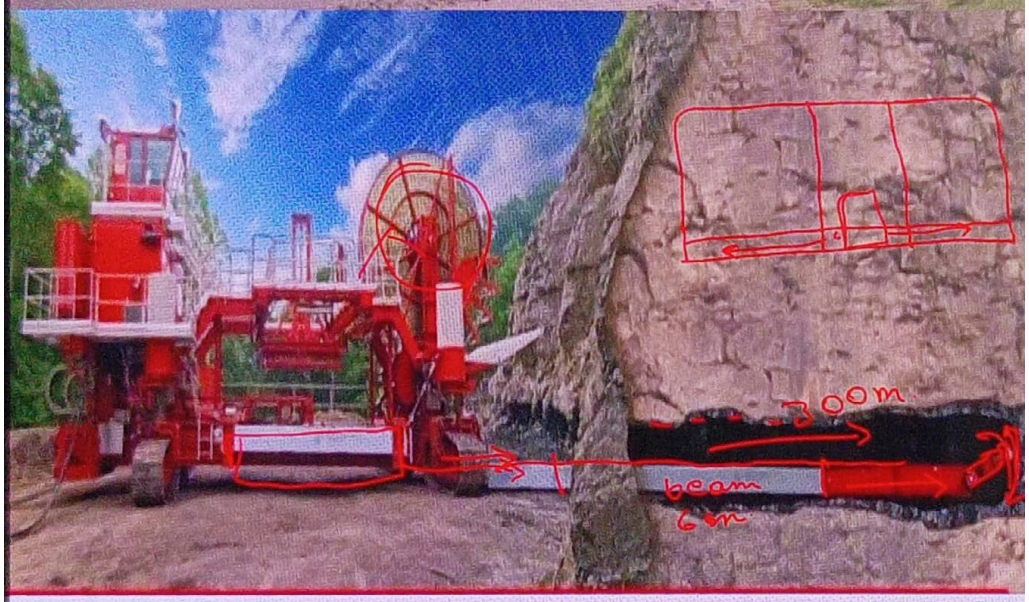


Limiting Ratio in Coal mines.

$$\text{Stripping Ratio} = \frac{\text{Vol.}^{m} \text{ of OB in } m^3}{\text{weight of recoverable mineral in tonne.}}$$

reserves.

① Manual Quarrying — 1.5 : 1
② semi-mechanised quarrying — 2 : 1
③ Mechanised Quarrying
↳ With dipper shovel, dumper comb.^{n} — 4 to 5 : 1
↳ with draglines → 8 to 10 : 1
↳ with BWE → 3 to 4 : 1



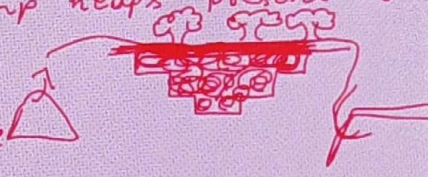
Advantages of Quarrying

→ No problem of Ventilation
→ No problem of roof control, supports
→ No problem of lighting in daytime
→ % of Coal extraction is high
→ High OMS (output per man per shift)
→ Much productivity / Profits
→ Quick returns on capital investment

→ Quick returns on capital investment
→ Dangers & hazards are less compare to U/g mines
→ There is no risk of gas explosion
→ Large scale mechanisation is possible
→ Gestation perid is less.

Disadvantages of OC Mining.

→ Work is affected by weather.
→ Land degradation by mining
→ Deforestation
→ Pollution (water, air, Land, Noise)
→ This method is uneconomic for workings deeper depths, cities & sea/rivers.
→ The quarried area or OB dump heaps present an unpleasant sight
→ High reclamation cost.
→ Handling of high unproductive material



→ Overall OMS is low due to large labour force engaged in OB removal in manual quarrying
→ Danger Zone → 500m

Production Procedure

① Site preparation → trees को remove करते हैं
→ Top soil and sub soil को remove करके reclamation के लिए store करके रखते हैं।

② Drilling & blasting → जब OB hard होता है, तब इसे blast किया जाता है।

③ Removal of OB → by dragline, shovel-dumper

④ Excavation, Loading & transport → Mechanised mines में coal को shovels / Hydraulic excavators की help से dumpers में load किया जाता

⑤ Reclamation →

Operations in o/c Mining

→ Leveling by dozing
→ Drilling
→ Bl...

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(3) Removal of OB → by dragline, shovel-dumper

(4) Excavation, Loading & transport → Mechanised mines में coal को shovels / Hydraulic excavators की help से dumpers में load किया जाता

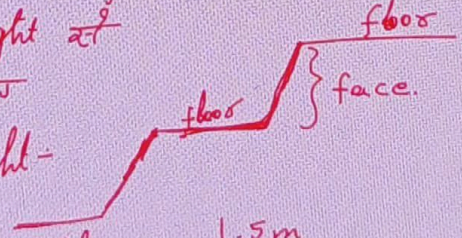
(5) Reclamation →

Operations in o/c Mining

→ Leveling by dozing
→ Drilling
→ Blasting
→ Removal of OB
→ Dumping, Back filling, Reclamation
→ Extraction of coal
→ Transportation to CHP or loading system.

Formation of benches

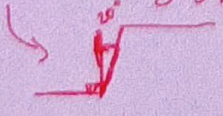
→ Slope angle → 45° से ज्यादा नहीं होना चाहिए
→ 2 elements of benches → floor & face
→ floor की width height से कम नहीं होनी चाहिए
→ Loose material → bench height ↓ not more than 1.5m



Gradient of road for tyre mounted → not exceed 1 in 10.

Coal → not more than 3m.
Sand stone / hard rock →
Manual quarry → 3m – 4.5m.
Mechanised quarry → more than 5.5m
Bench height → depends on Boom height of excavator.

bucket capacity → 2 m^3 → bench height → 6m – 8m.
→ 3.5 m^3 → " " → 12m



bench floor width → 15m
in mechanised mines

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Standards & Parameters for haul roads

→ HEMM → Heavy Earth Moving Machine.

→ Haul Roads → one way traffic

Two way Traffic

Road width

one way Traffic ① → largest vehicle width + 5m

Two way Traffic ② 3 times width of largest vehicle + 5m

One way traffic. Divider

→ In bends / Corners → Clear View distance → 3 times of braking distance → 40 km/hr

bends/corners 15m 5m

→ If it is not Possible → Provide 2 separate roads

↓ width → 2 times of largest vehicle + 3m

→ Strong divider → lighting, reflectors

→ haul road gradient → not steeper than 1 in 16

→ Ramp → Gradient → not steeper than 1 in 10

↳ Length → not more than 50m.

↳ use → for crawler mounted machines

→ Parapet wall / Embankment / Berm.

→ top width → not less than 1m

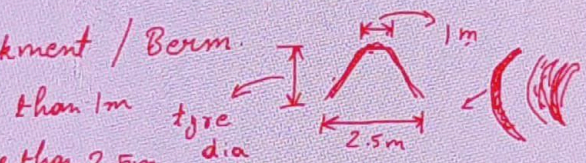
→ bottom width → not less than 2.5m

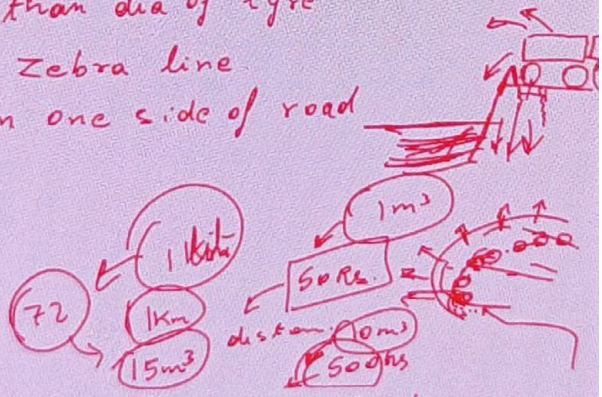
→ Height → not less than dia of tyre

→ At every curve → Zebra line

→ drainage system on one side of road

→





Manual o/c working in Coal

→ quarriable area को sections में divide करके extraction किया जाता है।

→ Coal in some sections & OB in others

→ हर section में छोटे - छोटे Pillars को छोड़ दिया जाता है। measurement purpose के लिए

→ Rabi or witness or Insitu Pillar

19:36

- Coal in some sections & OB in others

→ हर एक section में छोटे - छोटे Pillars को छोड़ दिया जाता है। measurement purpose के लिए

→ Sakhs or witness or Insitu Pillar
↳ height → not more than 2.5m
if height is more than 1.25m then base dia not less than 1.5m

Removal of OB

→ 4.5m x 4.5m का area हर एक Team को दे दिया जाता है।
↳ avg output → 2.8 m^3 per day
↳ In soft Rock

→ Hard rock → by drilling & blasting
↳ drilling → (1) hexagonal steel rod with chise
(2) Compressed (Jack hammer

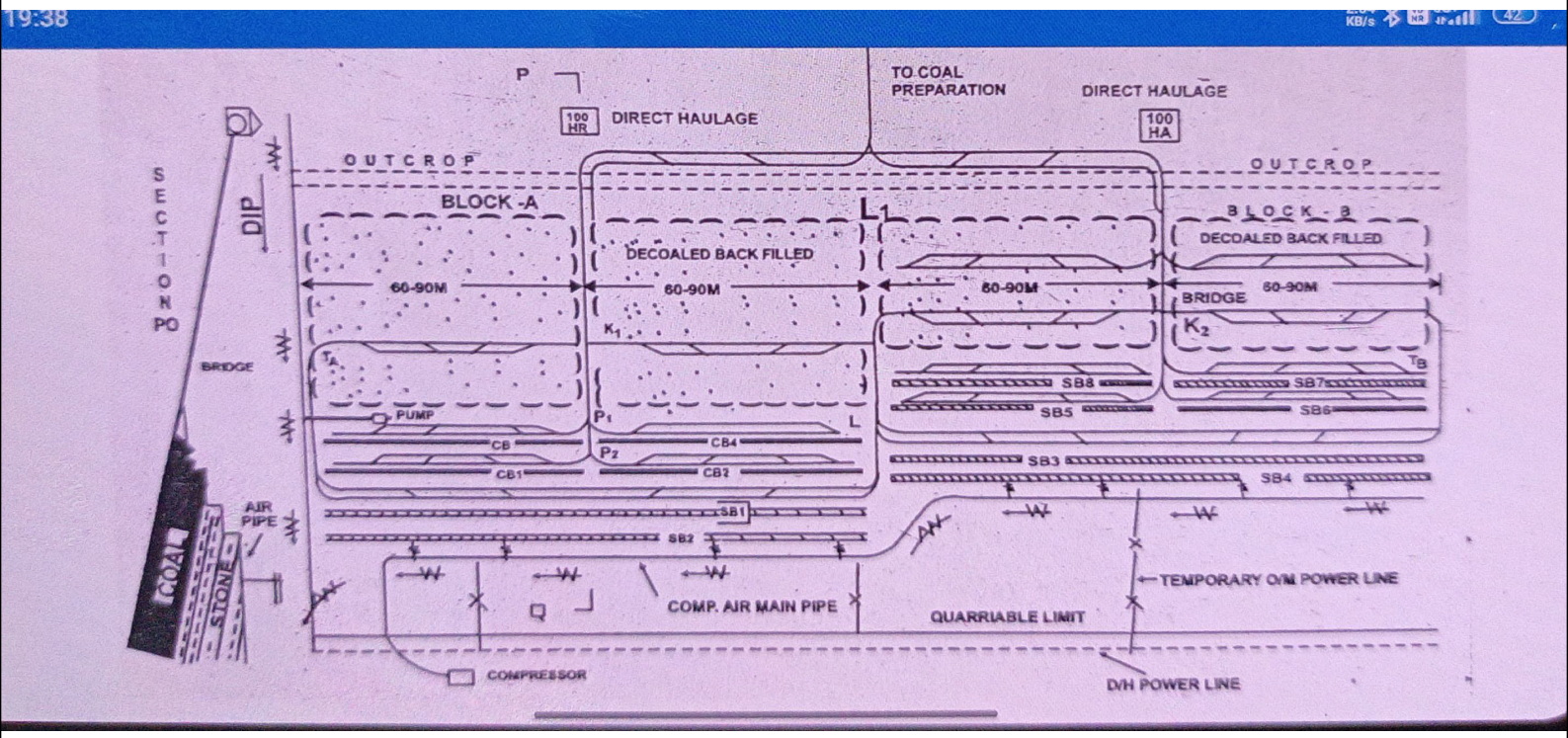
→ Hexagonal steel rod with chiselend method
↳ Small quarry में होता है।
↳ output → 50 - 100te coal/day
↳ hole depth → 1.2m - 1.5m
↳ One man can drill 5 - 8 holes of 1.2md in one shift

→ Compressed air drilling method
↳ supply pipe → dia - 50 - 100mm.
↳ Two workers → 40 - 50 drills करते हैं।
→ depth of hole → 1.5m

→ spacing b/w 2 holes → 1.2m to 1.5m
↳ blasting with gun powder

→ OB को tipping tubs में load किया जाता है
↳ (0.73 m^3 capacity)

→ hauled by → direct / endless haulage
→ haulage tracks → on benches.
→ Backfilling → Coal extract करने के बाद OB को Dump करने की Process को Backfilling कहते हैं।


P
TO COAL PREPARATION
DIRECT HAULAGE
100 HR
DIRECT HAULAGE
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OUTCROP
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DIP
BLOCK -A
L1
BLOCK - B
DECOALED BACK FILLED
DECOALED BACK FILLED
60-90M
60-90M
60-90M
BRIDGE
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K1
K2
BRIDGE
TA
TB
SB8
SB7
PUMP
P1
SB5
SB6
L
CB
CB4
P2
SB3
SB4
CB1
CB2
SB1
AIR PIPE
SB2
COAL
STONE
COMP. AIR MAIN PIPE
TEMPORARY O/M POWER LINE
QUARRIABLE LIMIT
COMPRESSOR
D/H POWER LINE

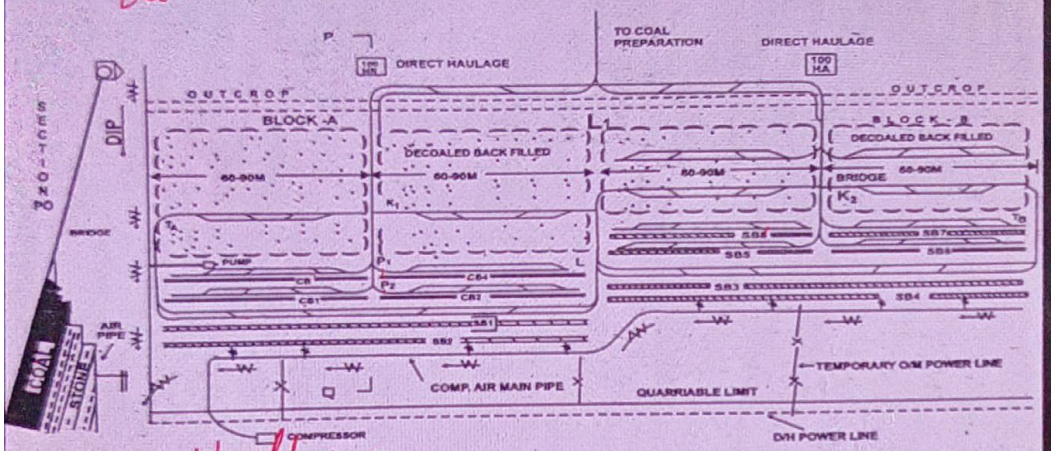
Extraction of Coal

→ Coal में electrically operated drill m/c को prefer किया जाता है।
↳ Lightness & better performance.

→ Spacing → 1.5m - 2.2m.
→ hole depth → 1.2m - 2m
→ 1 kg explosive → 10 - 12 tonne coal.
→ Permanent installations → haulages, compressors, power transmission lines.
→ Same track for loaded/empties.
↳ gradient 1 in 80 → in favour loaded.

Loaded →

Blocks → 120 - 180m.



Bench height → 3m.

Fig. 5.1 Layout of a manual quarry (coal). W with indicates water drains

Mechanised O/C Mining.

Preferred
↳ Thick mineral bed with mild inclination
↳ continuous.
↳ at low depth
↳ Plentiful reserve.

→ Seam thickness less than 6m & reserve is less than 1 MT will not be worked by it.
→ Soft → Combination of dozer & scraper
→ Hard OB → Drilling & blasting.

Crawler mounted - Rough roads.
Tyre mounted → Smooth roads

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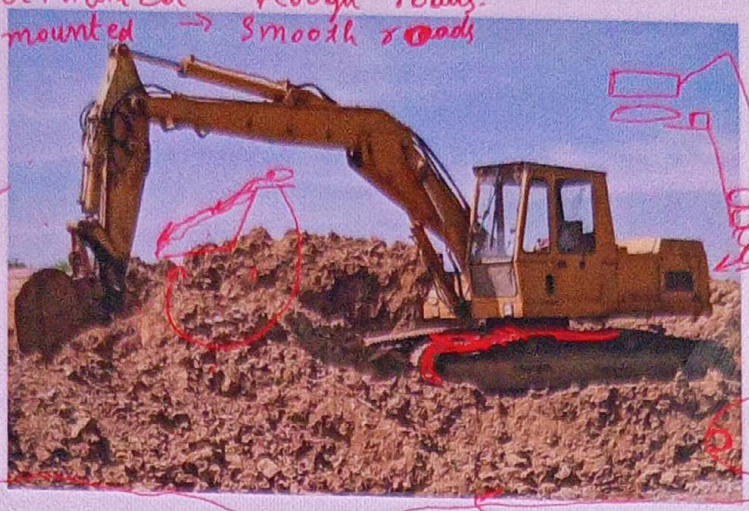
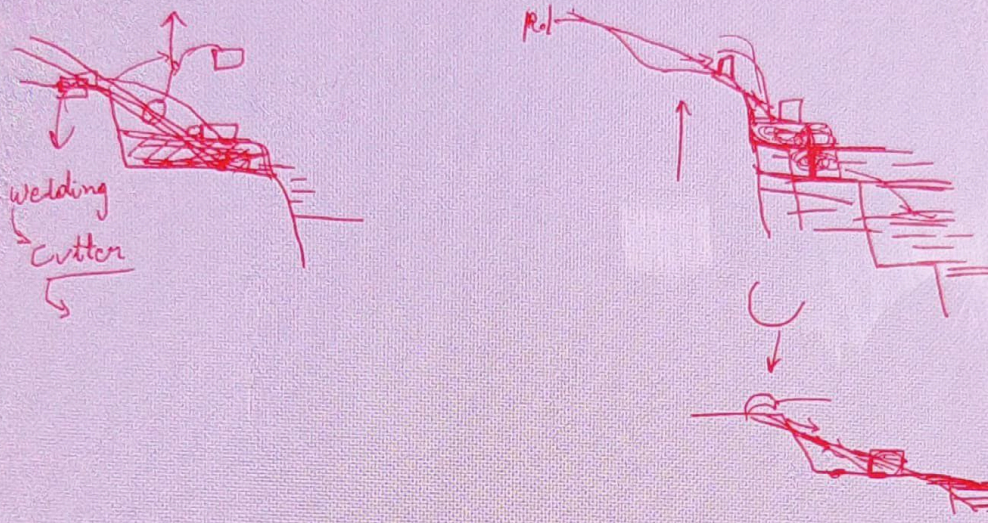
Crawler mounted - Rough roads.
Tyre mounted → Smooth roads





Crawler → rough surface → good gripping.
↳ Sharp turns

Diesel V/S Electrical

→ frequently moving m/c → diesel operated.

bulldozers, scrapers, graders, dumpers, tractor dozers.

→ Equipments working on a single site for longer Periods.
↳ diesel / electrically operated.
↳ dipper shovel, draglines, compressors, BWE, well hole drills.

→ electric shovel → fueling problem is avoided

19:41 0.07 KB/s 5G+ 41

→ electric shovel → fueling problem is avoided
↳ less maintenance
↳ eliminate gears.
↳ easy to operate.

In large HP shovels → Ward-Leonard system
or
draglines पर drive/operate
होते हैं।

→ Dipper shovel → bucket capacity - 3.5 m^3
→ diesel operated.

→ disadvantages of electric equipments.
↳ limited length of trailing cable
↳ Men to handle trailing.

→ Bucket wheel Excavator → Power supply → 11KV
↓
Step-down Transformer → 3.3 KV
↳ 400V

→ Power lines from mines
↓
gets damaged due to fly rocks during blasting.

Bull dozer
dozer

Bull - dozer
→ Bull dozer को dozer के नाम से जाना जाता है।
→ Attachments → ① Pusher blade → front portion

Bull - dozer

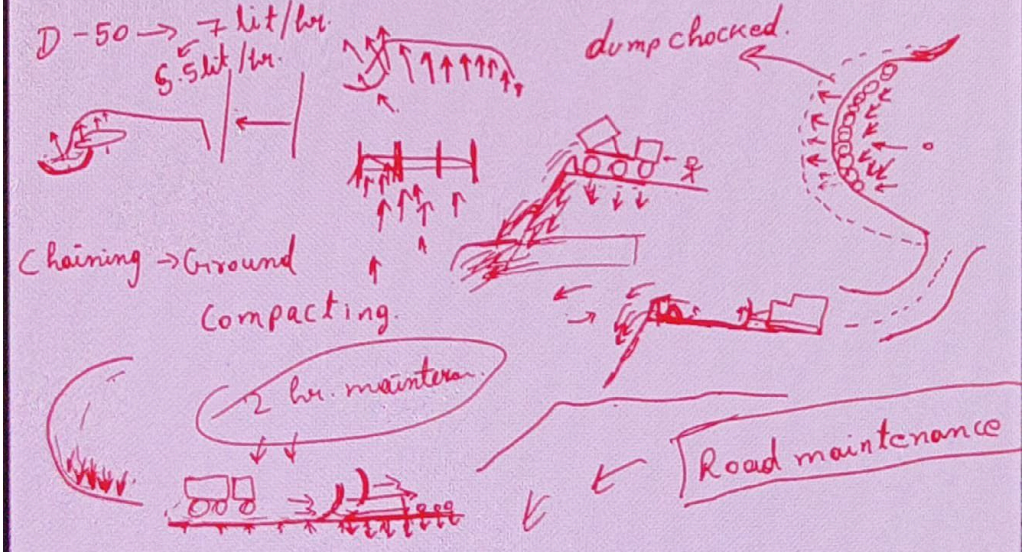
→ Bull dozer को dozer के नाम से जाना जाता है।

→ Attachments → ① Pusher blade → front portion
② diesel operated power unit
③ crawler chains / rubber tyred wheels → for lifting
④ Rams → operated by hydraulic pressure
↓
to give horizontal tilt

→ Uses → ① Pushing loose material
② Digging earth
③ levelling & spreading earth & dump.
④ Grading & Compacting temporary roads.
⑤ Pushing mineral in bunkers / crusher (Ground level)
⑥ Towing dumpers.
⑦ Pushing large boulders.
⑧ Pulling down trees.
⑨ Push scrapers.

→ fork attachment वाले dozer को Ripper कहा जाता है।

→ A dozer can dig 1.2m - 1.5m deep.



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D-80

D-65

maintenance Cost

15-20 lg

Kolhapur

Scraper.

Scraper

→ Attachments → ① Diesel engine
② Pneumatic tyred wheels
③ Bowl at centre with cutting blade.

→ Pushed by dozer
→ Blade cuts thin slice of earth → 75mm - 225mm for a distance of 30m.
→ Bowl Capacity → $3m^3 - 20m^3$
→ Loading Time → 1 minute.

working of Scraper

① Scraper full होने पर bottom opening को cables/ropes की help से बंद कर लेता है।
② Bowl को lift कर लिया जाता है, और अपने Power पर dumping yard तक जाता है।
[illegible] yard में bottom opening खोल कर

की help से बंद कर लेता है।

(2) Bowl को lift कर लिया जाता है, और अपने Power पर dumping yard तक जाता है।

(3) Dumping yard में bottom opening खोल कर Scraper move करता है।

(4) 30m - 70m तक 150mm - 250mm thick earth की layer Unload कर देता है।

Limitation → Hard rock, boulders, sump soil.

Hard Ground → Rip the surface before loading by scraper

Cycle time → 5 to 6 minutes for loading and Unload if distance of a trip is 300m.

Ripper

→ Ground cutting m/c by furrows → 0.6m - 1m deep.
→ Crawler mounted
→ Diesel operated
→ Ripping tool operated by hydraulic pressure.
→ Suitable for → Soft rocks i.e. below hardness 5 on Mohr's scale

Refraction Seismograph → Rocks की rippability पता करने वाला instrument

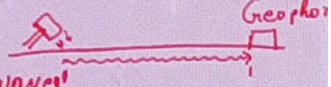
Principle of Ref^{n} Seis^{h}

→ Sound waves different material में different velocities से travel करते हैं।
↓
यह materials के consolidation पर depend करता है।
→ Poorly consolidated material → low seismic wave velocities
→ highly consolidated material → high " " "

→ Speed of sound in water is more than air.
→ Sound is a type of wave.

Equipments for Seismic Analysis → wave

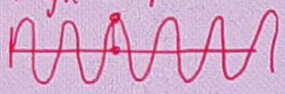
→ ① Refraction Seismograph → यह time interval बताता है hammer strike & geophone पर seismic wave recieve होने का।



→ ② Geophone → Reciever of sound waves.
⇒ detecting frequency → 1 Hz – 100 Hz
→ converts mechanical vibrations into electrical analogue.
→ electrical signals को amplify करके monitoring station पर transmit कर देता है।

Low amplitude

High amplitude



→ ③ Sledge Hammer & Impact Plate → Source of Sound wave
→ ④ 30m Tape → To measure distance b/w geophone & Impact point.

→

Selection of Ripper

① Down pressure on tooth → तोड़ सकता है कि नहीं
② Ripper HP → Rock को break करते हुए tooth आगे बढ़ेगा की नहीं।
③ Weight → Ripper का weight इतना होना चाहिए कि full HP का use tooth को advance करने में लगे।

आगे बढ़ेगा की नहीं।

(3) Weight → Ripper का Weight इतना होना चाहिए कि full HP का use tooth का advance में लगे।

Tractor Shovel

→ Diesel operated
→ Bucket as front attachment
→ Also called front end loader or pay loader
→ Mounting → Pneumatic tyres / Crawler chains
→ Bucket operation → Raise or lower
→ Vertical tilt
→ hydraulically / mechanically
→ Pusher fan
↳ bucket से गिरने वाले dust को operator/engine air intake में जाने से रोकता है।
→ Uses → ① To load stacked mineral ② To push into ground level bunker
→ Bucket capacity → more than 0.57 m^3

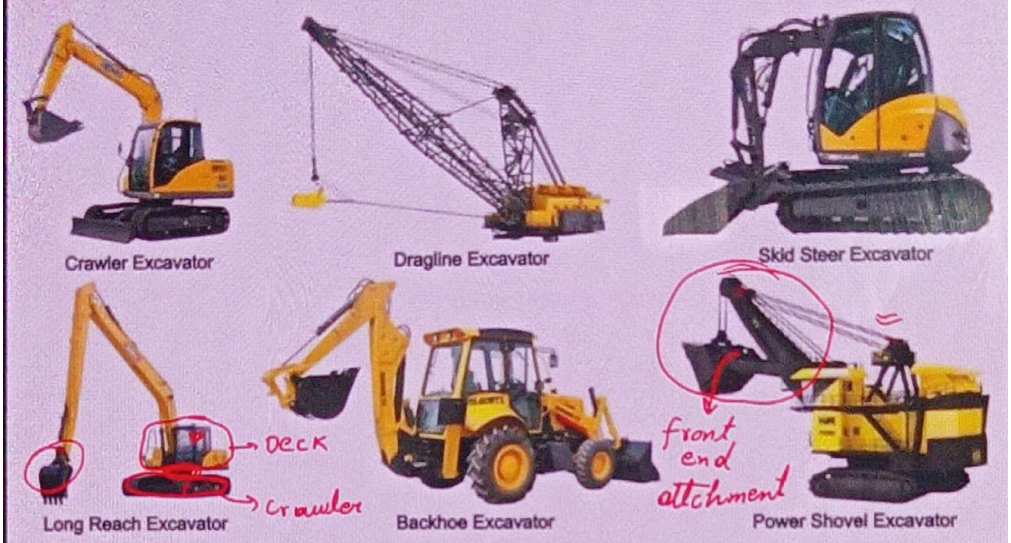
19:49 11.4 KB/s 5G+ 40

Excavators

① Power shovels → Dipper shovel, stripper shovel, backhoe
or
pull shove
② Draglines
③ BWE

Power shovels

→ Disel/Electric operated
→ यह fragmented rocks को lift करके swing करता
है और dumpers / spoil heaps में डालता है।



Components of Power shovel

① Pneumatic tyres / Crawler chains —
② Deck / Cab → all controls for operation =
→ Cables / ropes
→ operators seat.
→ It swings 360°
③ Deck swinging mechanism.

3 structural divisions of Power shovel.

① Revolving unit → head / Torso
② Mounting / Travel Unit.
③ Arms & hands.
↓
Five front attachments make it
① Crane
② Clam shell
③ Hibber shovel

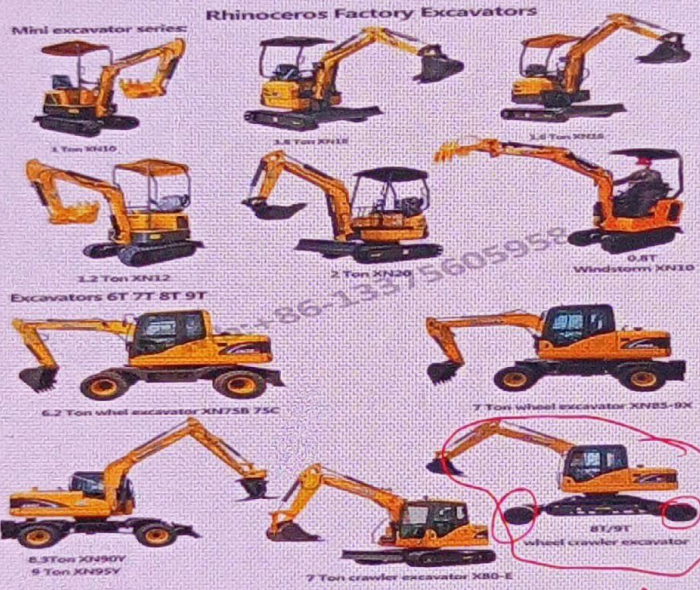
19:50 0.00 KB/s 40

1. Crane
2. Clam shell
3. dipper shovel
4. Dragline
5. Pull shovel / Back hoe.

Dipper shovel.

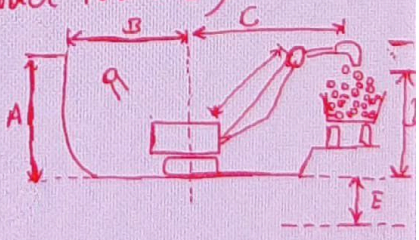
→ For soft & fragmented rocks from a bench
→ Mounted on crawler chains
→ Power Unit → Electrical motor at 3.3 KV / Diesel
→ Bucket capacity → $1 m^3$ to $4.5 m^3$
→ Used for loading dumpers.
→ During operation यह bench के toe से 3 to 5m की दूरी पर खड़ा होता है।

→ इसके teeth loading के कारण damage होते है।

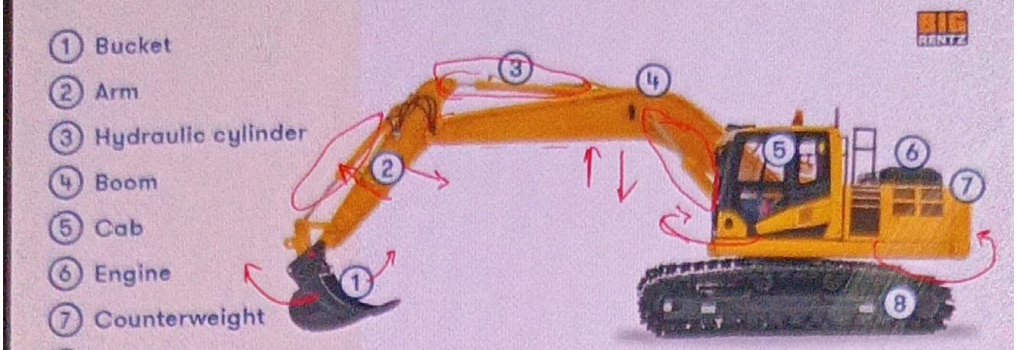


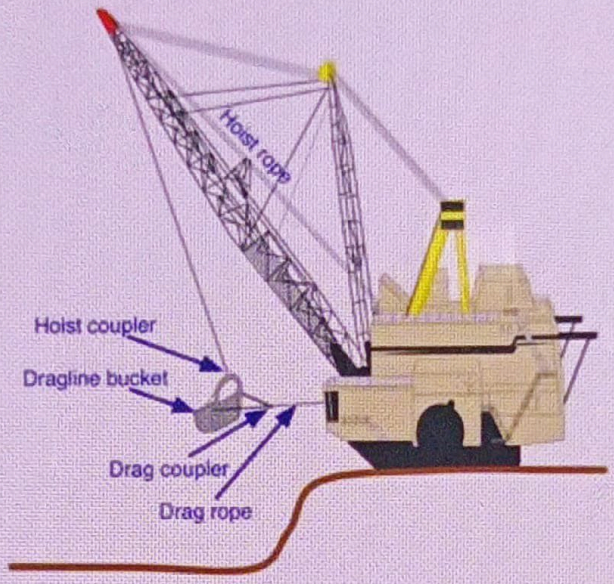
→ Hydraulic pressure से operate होने वाले shovel को hydraulic shovel कहते है।
↳ eg → Porclain shovel of L & T

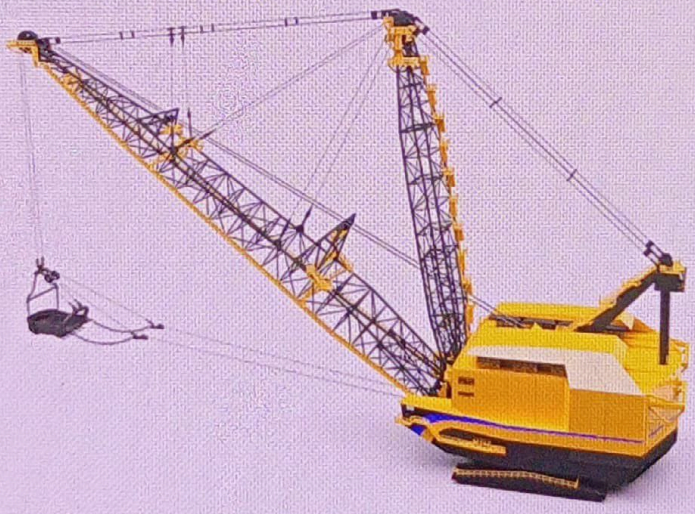
→ TATA dipper shovel (Model 1055B)



→ Boom angle → 50°
F → Boom length → 8.53m.
A → Cutting height → 10.83m
B → Cutting radius → 11.96m
C → Dumping radius → 9.51m
D → Dumping height → 7.25m
E → Cutting depth below crawler level - 2.51m.







380 → 3.8m³
450 → 4.5m³

0.9m³
1.2m³

19:51
0.00 KB/s
5G+
40
380 → 3.8m3
450 → 4.5m3
SANY
0.9m3
1.2m3

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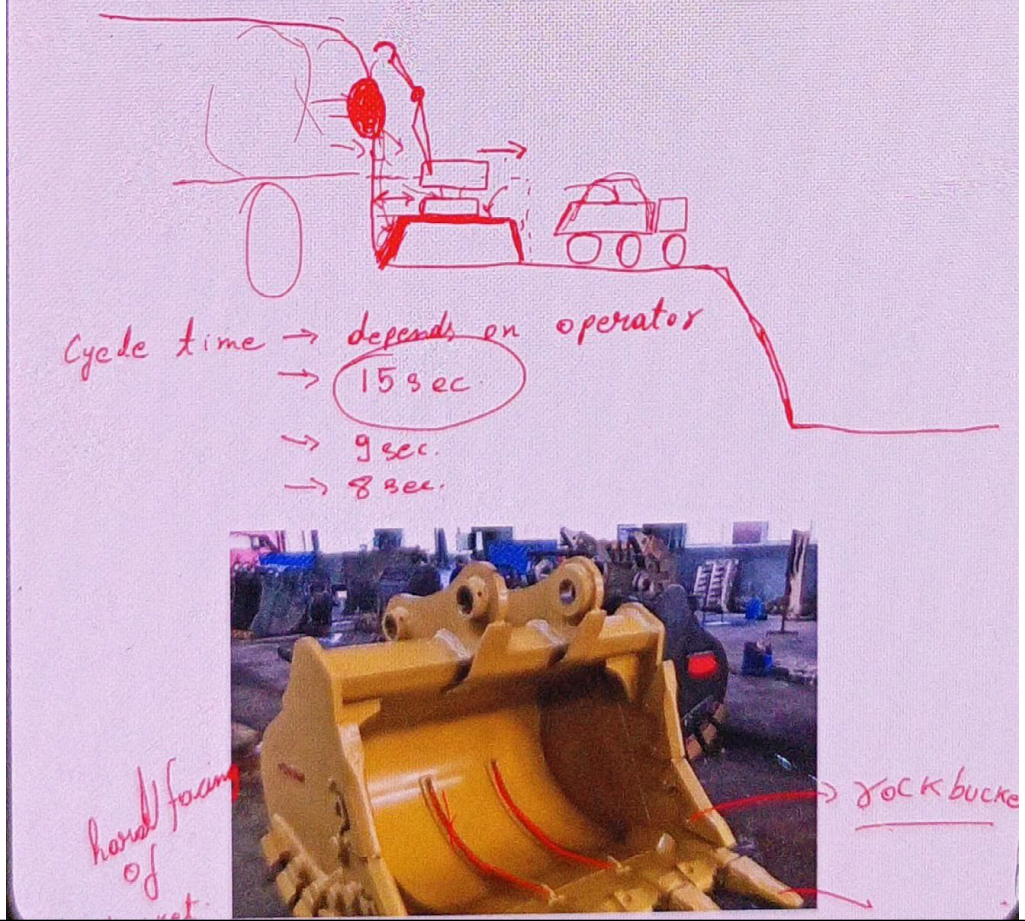
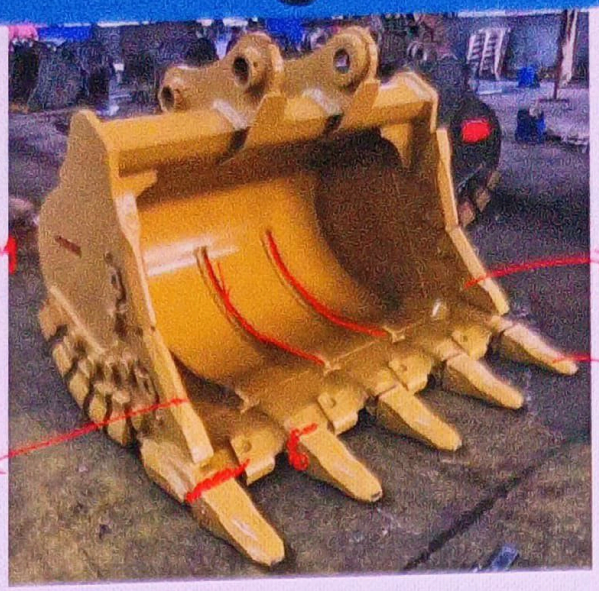

Cycle time → depends on operator
→ 15 sec
→ 9 sec.
→ 8 sec.
hard facing of
rock bucke


Hand/foam of bucket
Rock bucket
Teeth
Side cutter

Arm bolt.

VOLVO
VOLVO

Canopy
Container
15m³
TATA

Container
15 m3
Canopy
TATA
Freq

MAN
Truck Junction

Hydraulic
Jack

SANY
FIRST TIME IN
INDIA
SY800-10H3 WITH INTEGRATED
SANY
SANY
SY800 HD

19:55 KB/s

Dumpers / Tippers

→ hydraulic system पर काम करते हैं।
→ इसमें एक steel body का container होता है open at the top.
→ Swing of container from horizontal → 70°
→ Hydraulic system to tipping.
① oil tank से oil hydraulic pump में under gravity जाता है।
② जब driver Power take off lever (PTO) को engage करता है तो engine pump को start करता है।

③ High Pressure के साथ oil pump से Control valve में जाता है।
④ Control valve का lever 4 अलग Position पर रख सकते हैं।

ⓐ Raise Position
High pressure oil hose pipe से hoisting cylinder के bottom में जाता है। Oil hoist के top से Control Valve के पास वापस जाता है via hose pipe जिसमें piston rod होता है।

ⓑ Hold Position
Control Valve & hoist passage close होता है oil cylinder में ही रुका रहता है।

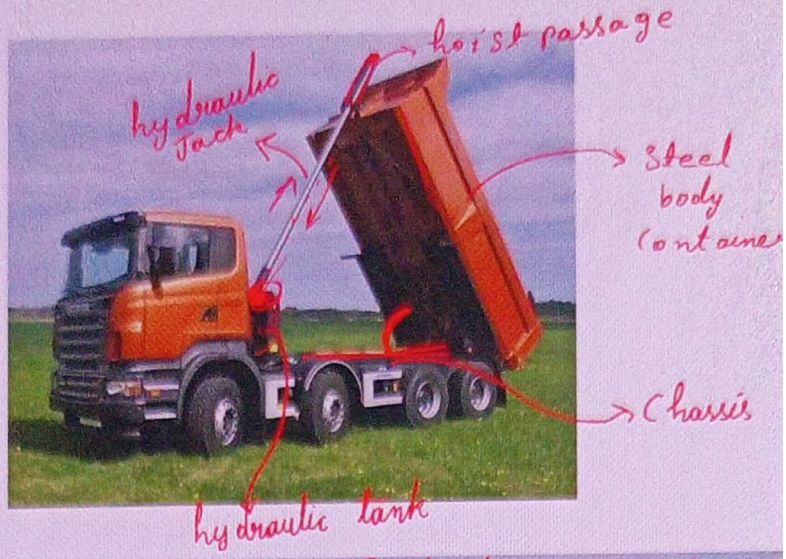
ⓒ Float Position
Control Valve & hoist passage open होते हैं इस case में oil कहीं से भी निकल जाता है। Depend करता है की force किस direction में है।

ⓓ Lower Position
High Pressure oil top पर जाता है और फिर Control Valve के through hoist bottom से tank में वापस चला जाता है।

→ Brakes on dumpers are operated by compressed air.

Hydraulic Retarder (Hydrotarder)

→ यह एक ऐसा device है जो dumper की speed को limited करता है। जब dumper steep down slope में travel करता है।
→ basically यह governor का काम करता है



Road Grader

→ Road की leveling & smoothening के लिए use होता है।

→ length of Grading blade - 3.5 - 4m

Rock drills

→ By percussive or rotary action.
→ Hole dia upto 100mm.

Classification of rock drills

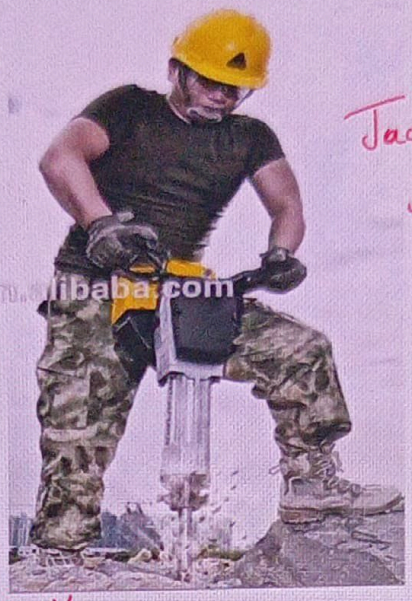
1. Jack hammers (also called sinkers)
2. Drifter
3. stopers
4. wagon drills

Jack hammer drill

→ weight → 15 to 25 Kgf
→ Depth → 2m.
→ Dia → 30 to 37mm.
→ It is hand held
→ Compressed air operated → Pressure 6 Kgf/cm
→ Drill rod is of hexagonal cross-section.

→ Compressed air operated → Pressure 6 kg f/cm²
→ Drill rod is of hexagonal cross-section.
→ इसमें Chisel bit, of tungsten carbide का लगा होता है।
→ 8 hrs shift → Two persons → 60 holes
→ 1.2 m to 1.5 m deep

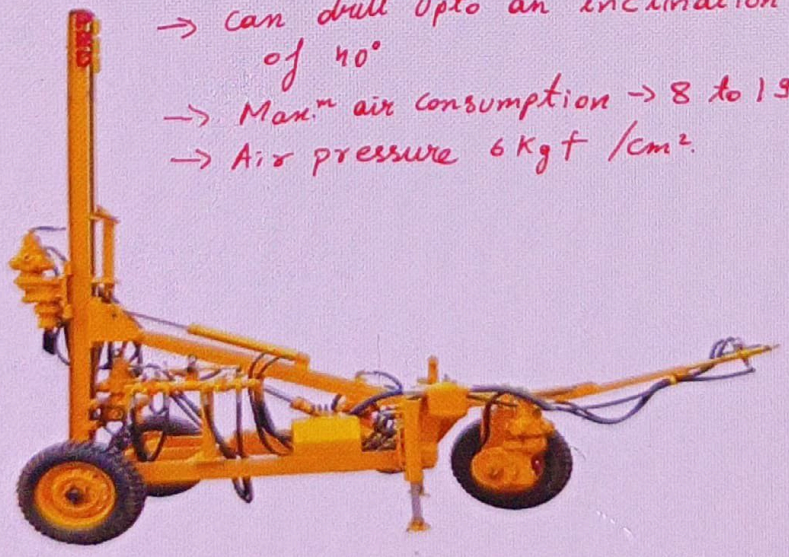
Air Consumption
2 to 2.5 m³/min of free air.



Jack hammer Drill.

Wagon Drill

→ Compressed air वाला Drifter mobile frame पर mounted होता है।
→ Mast पर Up-Down करता है।
→ Frame usually tyre mounted होता है।
→ Hole dia → 50 mm to 100 mm.
→ Hole depth → 3m to 15m.
→ Mast height → 3m.
→ Drifter provides rotary + percussive drill
→ Tungsten Carbide bit.
→ 8 hr. shift → 60 - 70m.



→ can drill upto an inclination of 40°
→ Max.m air consumption → 8 to 19 m³/m
→ Air pressure 6 Kg f/cm².

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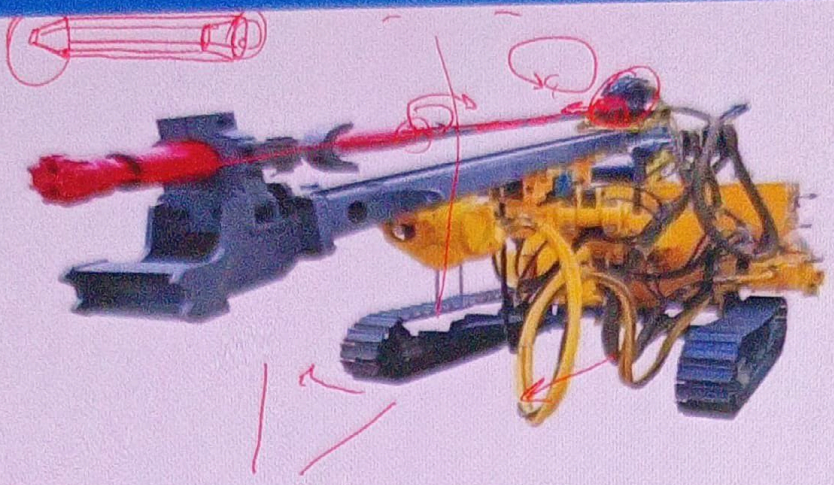
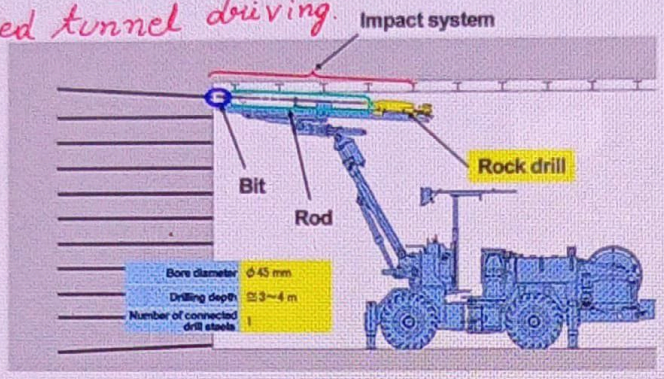


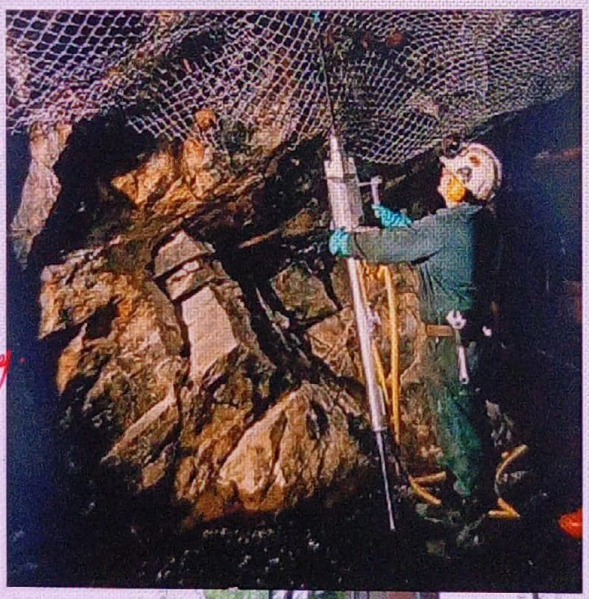
Drifter

→ for horizontal drilling
→ used tunnel driving.
→



Stoper

→ for upward drilling
→ Used in mine stopes
→ Normally wet drilling.



Down the Hole Hammer

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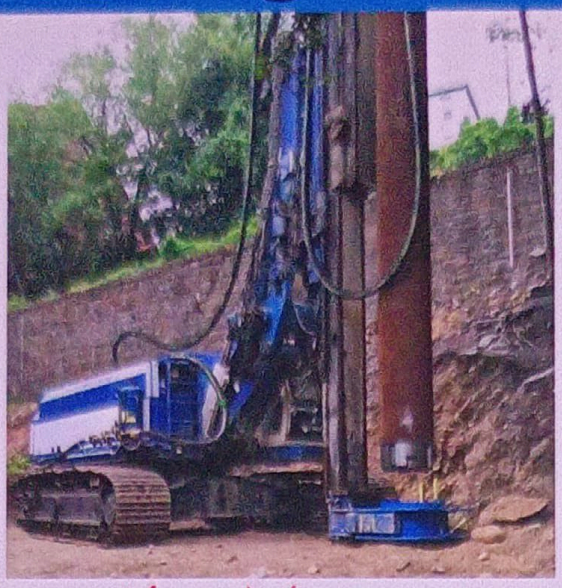
Down the Hole Hammer



Down the hole Hammer

→ It is a large size wagon drill.
→ Drill bit → Carset bit / button bit.
→ No. of blows → 500 to 2400 per min.
→ Rotational speed of drill → 15 – 25 rpm.
→ Rotary head का use drill rods loose or tight करने के लिए भी किया जाता है।
→ Air Consumption → at 7 Kgf/cm² is 5.5 m³/mi
→ HALCO drills → 100mm to 125mm dia.
→ Length without bit 94 cms.
→ weight without bit 31 Kg.

Hydraulic Wagon Drill

→ इसमें Compressor की जगह hydraulic pressure use होता है।
→ इसमें air cooled diesel engine use होता है जिसमें 1201 exhaust air नहीं रहता है और noise भी कम produce होता है।
→ drill hole dia → 65mm to 127mm.
→ depth of holes → 12m.
→ air pressure → 10 Kgf/cm²

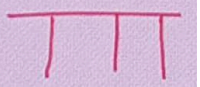
Well-hole Drill

→ Crawler mounted
→ Diesel / electric operated
→ hole dia → 125mm to 300mm
→ depth → 6m to 18m.
→ Mast height → 3m to 6m.
→ Percussive & rotary drills are used.
→ Rotary drill → Tricone bit.
→ Percussive drill → Crossbit button bit.

→ hole dia → 125mm to 300mm.
→ depth → 6m to 18m.
→ Mast height → 3m to 6m.
→ Percussive & rotary drills are used.
→ Rotary drill → Tricone bit.
→ Percussive drill → Crossbit button bit.
→ Air motor & rods को bits को tight/loose करने के लिए use होता है।
→ Drill rods का Up-Down movement chain से होता है कि Piston type air motor से operate होता है
→ Compressor holes को clean रखता है।
→ 3 hydraulic jacks की help से m/c का levelling होता है।
→ 8hr shift → 20 holes of 9m deep & 200mm dia.
→ Only vertical holes can be drilled.
↓
कुछ drill m/c से 20° inclination पर भी होल होते हैं।

Inclined Drilling

→ Soft OB को ripper and scraper-dozer combination से remove किया जाता है।
→ Blast holes की help से भी blasting करके remove कर सकते हैं।
↓ ↘ vertical.
horizontal
↳ 30° inclination max^m



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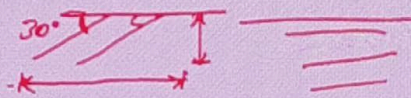
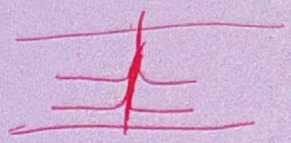


→ Problems due to more horizontal.
① Increases hole length
② difficulties in charging & stemming.
→ ड्रेस type की drilling से bench के toe को remove कर सकते हैं।

Layout of mechanised quarry

→ Layout depends on



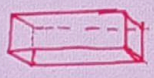
1. Shape, size & dip of deposit.
2. Depth of mining activity
3. OB thickness
4. Surface topography
5. Desired prod.ⁿ
6. Transport system for mineral & OB
7. Arrangement for disposal of debris
8. Type of mechanisation & finance available.

The layout of quarry should show the following.

1. Position of OB & mineral deposit.
2. Access to benches & exit roads for dumpers.
3. Position of backfilling area.
4. Location of m/c which operates from one site over a longer period.

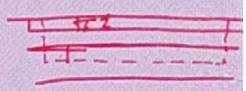
→ Property को area में divide किया जाता है।
100 से 300m long.

→ Starting में box cut / trench बनाते हैं
by → Scraper, dozer, shovel ($2m^3$)



→ hards rocks में blasting करके trench का formation होता है।

→ Advance stage में 2 trench बनाते हैं।
↓ OB
↓ mineral.
↳ parallel to each other



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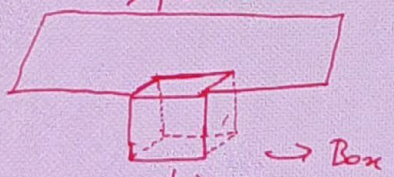
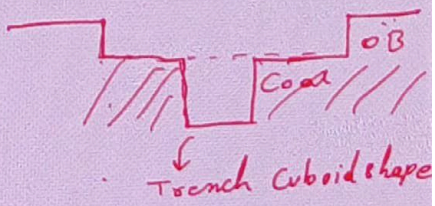


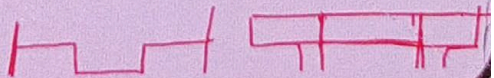


→ कम bench रखने से dumpers के लिए Consisted नहीं होता है।

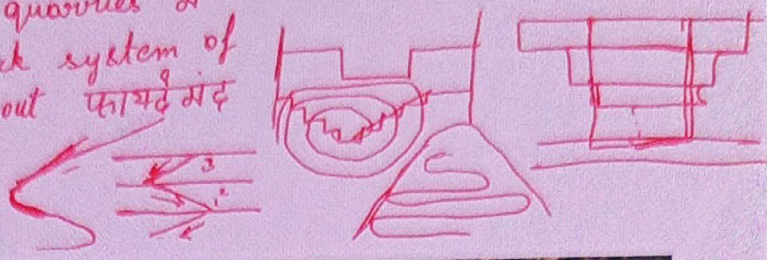
→ Minerals को conveyor belt से CHP or mineral processing plant में भेजा जाता है।

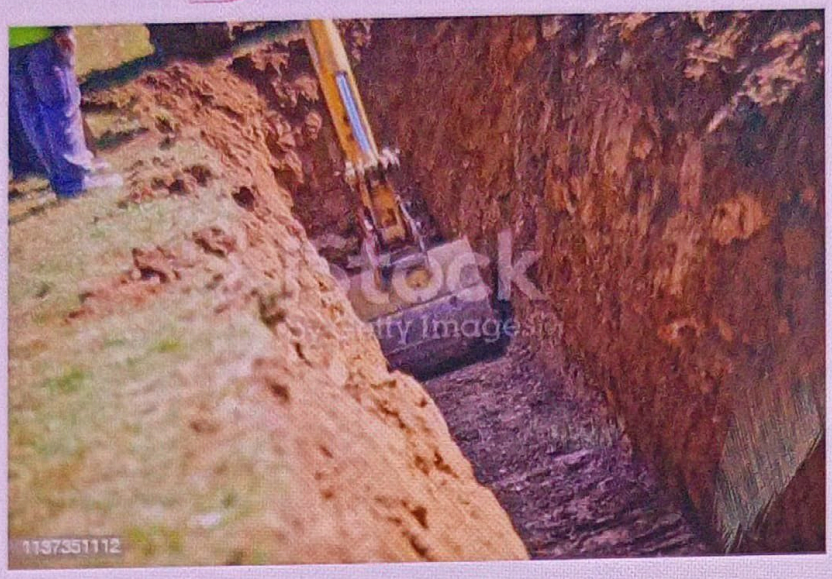
→ Large depth के लिए one trench ही बनाना economical होता है।

→ Deeper quarries में Switchback system of



→ Deeper quarries में Switchback system of track layout फायदेमंद होता है।





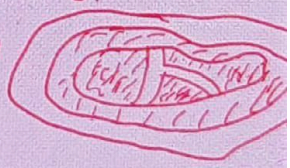
Quarry at an advanced stage with dumper dipper shovel combination.

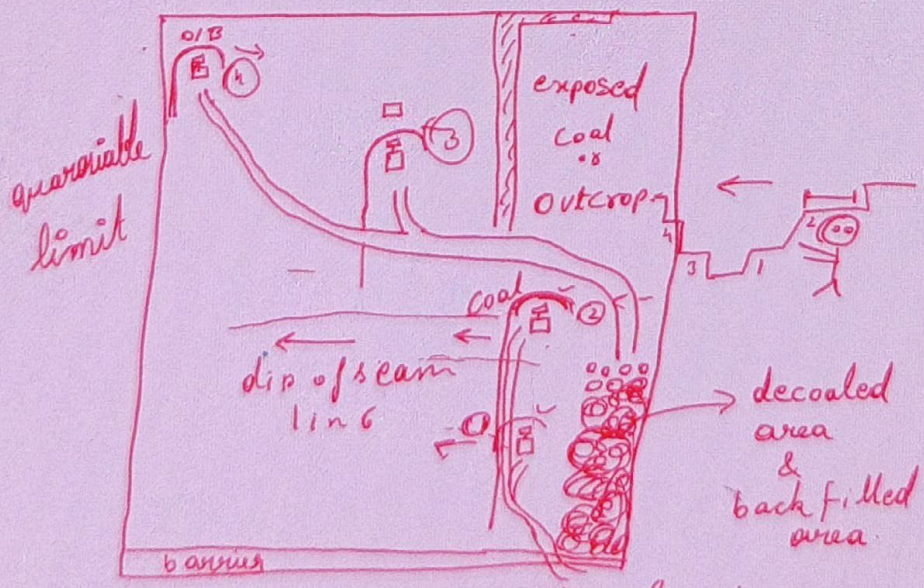
→ Seam thickness 18 m.
Dipping → 1 in 6.

→ Naming of benches → Bench no. 1, Bench no. 2 etc
or
↳ by reduced level → 500m bench, 510 bench 520 m etc.

→ Pumps को set किया जाता है dry operation किया जा सके।

→ 40 से 60m के width के strips में divide कर सकते है।





→ 45m to 60m के width से dumpers easily move कर सकते है।

1+1 ... सकते है।

→ 45m to 60m की width में dumpers easily move कर सकते हैं।

→ min.m 18m width रख सकते हैं।

→ हर एक strip में एक bench होता है जिसमें shovel और drill m/c रहता है।

→ bench का advance along the strike होता है।

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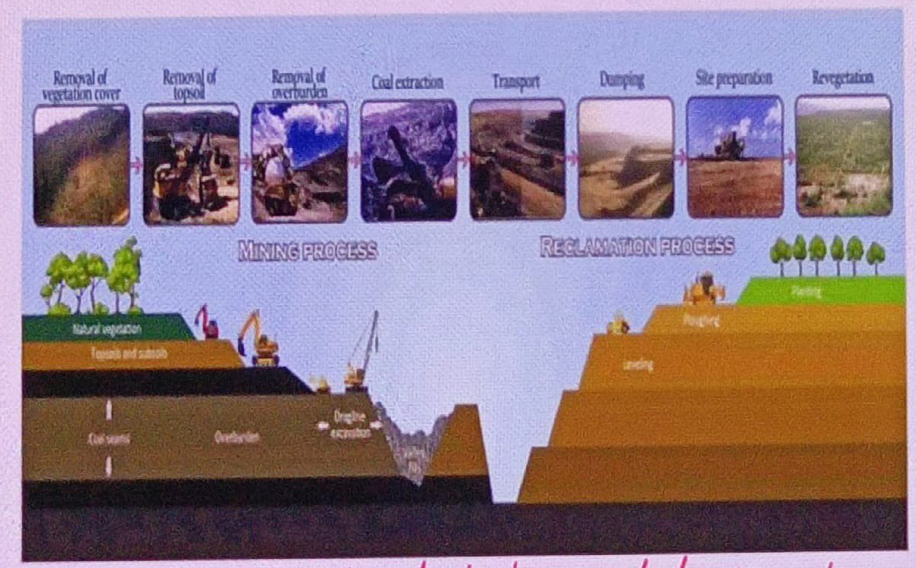
Reclamation

Primary reclamation process

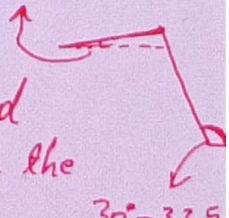
1. Physical reclamation
   - → larger size boulders के ऊपर filler की layer डाली जाती है। → to divert rainwater
     - Thickness (0.5m)
   - → over the filler layer 1.5m high sub-soil डाला जाता है।
   - → Above sub-soil 0.5m thick layer of top soil.



→ The faulted land shall be graded by dozer, ripper etc.

→ Grading of land varies from 0° to 30°

→ Ultimate slope angle of the side wall of OB Dump shall be around 30° to 37.5°. It depends upon the type rock.



land erosion को बचाने के लिए

30° to 37.5°. It depends upon the type rock. 30°-37.5

→ Grading land erosion को बचाने के लिए & slope stability maintain करने के लिए किया जाता है।

→ Gentle slopes → contour trenching

Steep slopes → geo-textile → retain moisture
↓
avoid soil erosion.

② Biological reclamation
→ Top-soil enrichment is done by bio-fertilize process.
→ Suitable fertilizer & manure are to be applied into the soil to cover up the nutrient deficiency.

Secondary Reclamation process
① Ecological restoration.
→ Reclaimed land में grasses or legumino plants के seeds डाल दिए जाते हैं।
& इससे N_2 content बढ़ेगा और weathering soil erosion को reduce करेगा।
→ Monsoon के starting में fast growing plants के seeds को spray कर दिया है।

② Hydrological restoration.
→ The soil must have enough water holding

(2) Hydrological restoration.

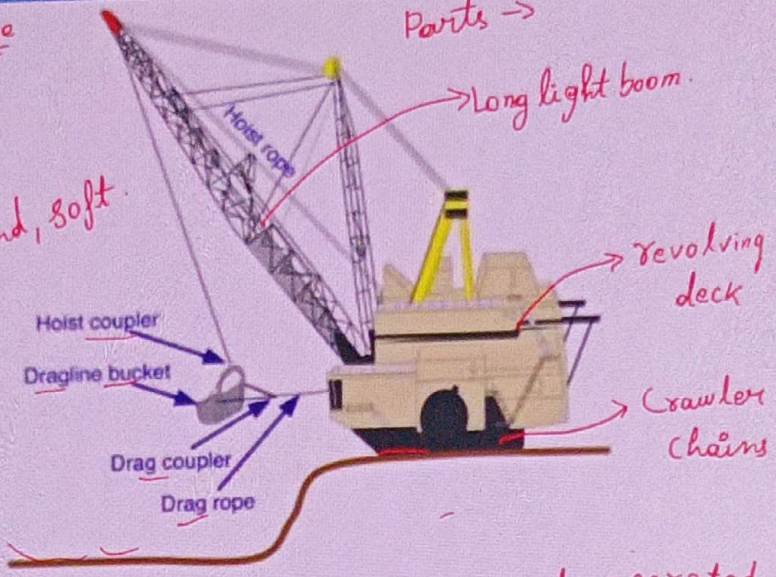
→ The soil must have enough water holding capacity.

→ with plantation it can be increased.

Dragline

Used for excavating earth, sand, soft.

Parts →



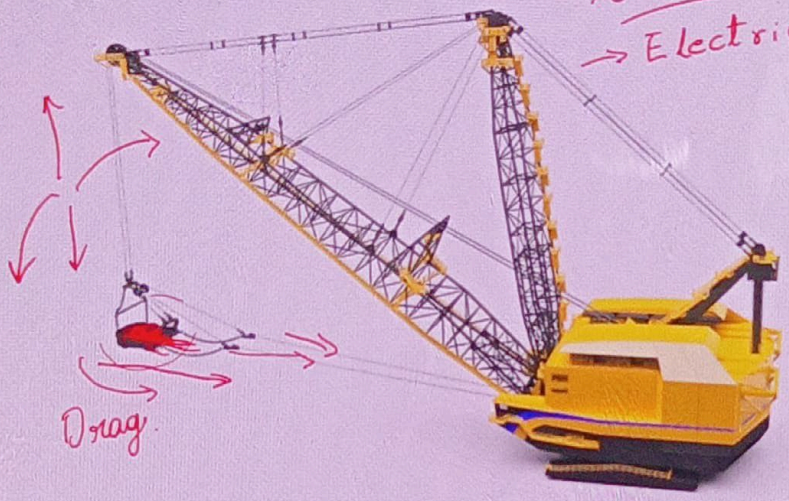
→ Long light boom.

→ revolving deck

→ Crawler Chains

→ Diesel operated

→ Electrical operated



Loading Capacity → 12 - 14 hours daily

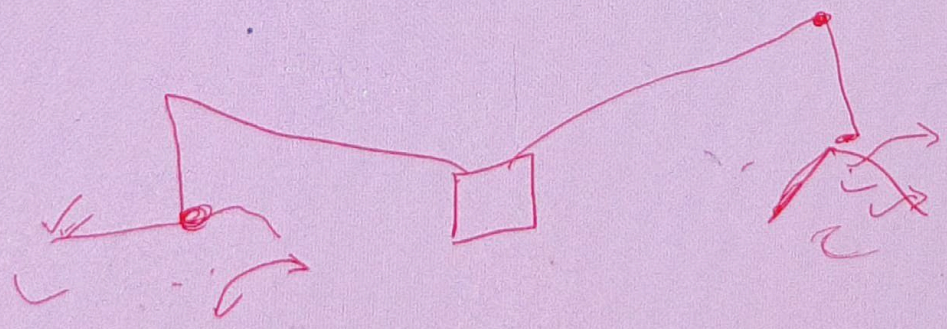
→ Bucket size

	Million m^3/year
4.5 to 7.5m^3	0.25 to 0.75
11.5 to 15m^3	1.5 to 1.7
23 to 30m^3	3 to 4.5m^3.

→ digging depth → It depends on the Capacity of hoisting drums.

→ Speed → 0.25 to 5km/hr.

→ walking dragline → Speed → 0.18 to 0.6 Km/hr.



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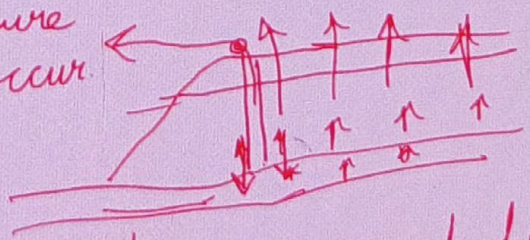
Neyveli Lignite Mines

→ Bucket Wheel excavator
→ 2 Thermal Power stations → 600 MW
→ 1470 MW
→ 40% elecity of Tamil Nadu
→ Lignite का Calorific Value → 2600 to 3000 KCal/Kg
→ Proximate analysis
↳ Moisture → 45 - 60%
↳ Ash → 3% - 6%
VM → 22 - 26%
FC → 20 - 26%
→ Density → 1.15gm/cm³ or 1.15tc/m³
→ Lignite was used in
① Two Thermal Power stations.
② Fertilizer plant → 1,30,000 tc/yea
to manufacture Urea.
③ Briqueetling → coal dust के छोटे blocks बनाते हैं जिसका इस्तेमाल आग जलाने के लिए किया जाता है।
④ Clay washing plant.

Reserve of Neyveli Lignite.

→ Area → 400 Km²
→ Reserve → 3300 MT.
→ Thickness → 8m.
→ OB → 110m.
→ Stripping Ratio → 5 : 1

→ Due water pressure accidents may occur.
↓
6-8 Kgf/cm²



→ Risk Water bursting during removal of OB
pumped → to maintain

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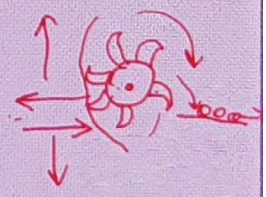
→ Risk Water bursting during removal of OB
→ Nearly 1,35,000 lit/min pumped → to maintain safe water level.
→ 15 - 20 te of water for 1 te lignite

→ Storm water Control.
↓
It is in cyclonic belt
↓
annual rainfall → 1200mm to 2000mm
→

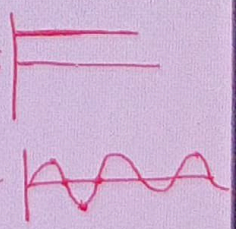
BWE

→ Used in OB, Coal, Soft ores.
→ 3 Units → bucket wheel
→ Connecting belt / Crawler
→ Loading belt
→ Manganese steel teeth
→ Push & Pulled.



No. of dumps / min → small model → 70
→ large model → 27

Power supply → AC Voltage
→ 25 kV
→ motors → 3300 V & 500 V
→ Step down transformer

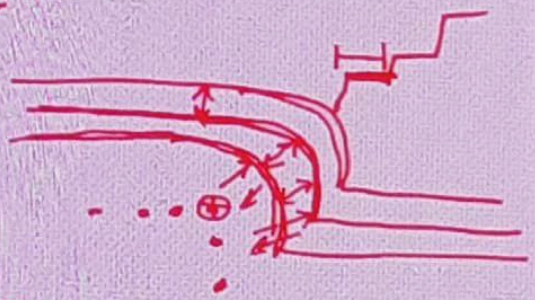


Methods of Working of BWE

Methods of working of BWE.

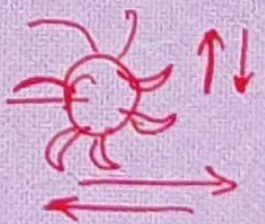
(1) Full block method.

↳ Push or pull



→ FBM is used where selective winning is not necessary.

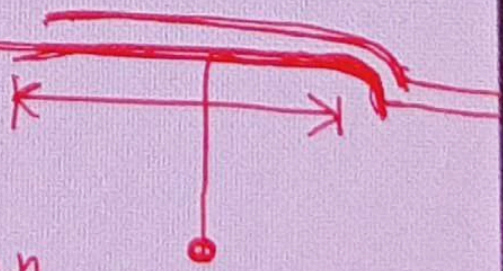
→ It excavates a block of width 45m to 100



Lateral Block method.

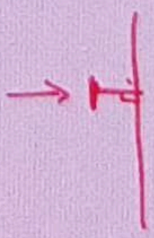
→ To remove waste materials

→ To remove mineral seams of minor thickness.



→ Length of block depends on boom length.

→



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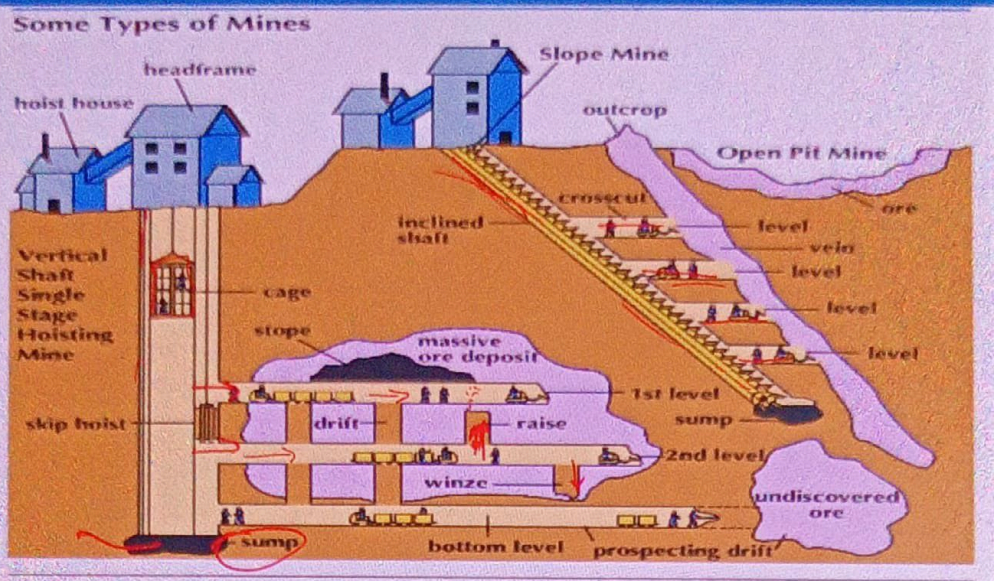


Access to a Mineral Deposit & pit top Pit-bottom layouts.

o/c mine → Haul roads & steps.

Shallow U/g mine → Incline & adit.

Deep U/g mine → shaft.

Incline & Adit.

→ Incline एक तरह की sloping road है जो कि Surface से mineral deposit तक बनाया जाता है।

→ अगर locomotive use नहीं होता है तो incline steeply dipping होता है।

↓

1 in 5 or 1 in 4

True dip → Max^{m} ∠ of dip on a rock bed
It is measured in a direction at right ∠ to the strike

Apparent dip → It is a dip measured in any other direction than the true dip.

AD < TD

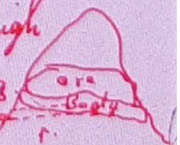
→ Haulage is in apparent dip for milder inclinat

→ अगर deposit general ground level से ऊपर है तो ground level से slightly rising roadway i.e. adit बनाते हैं।

→ Size of incline → 4.2m wide × 2m high

↓

for haulage & conveyor belts



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तो ground level से slightly rising ... i.e. adit बनाते हैं।

→ size of incline → 4.2m wide × 2m high

for haulage & conveyor belts

→ 2m × 2m → Incline for travelling.

Pit or shaft

→ for deposits at a depth of 30m or more.

→ Kolar gold mines & Mosbani mines have Inclined shaft

↓

Gradient 1 in 4 or 1 in 3

↓

Upto 30m depth.

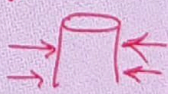
→ shafts को main shaft or Auxiliary shaft के नाम से नाना जाता है।

→ Main shaft mineral horsting के लिए use होता है।

→ Auxiliary shaft man-winding, ventilation, material transport, stowing के लिए use होता है।

→ Inclined shafts को dip के parallel बनाते हैं।

→ stresses के कारण shaft की verticality पर effect पड़ता है जिसके कारण collapse हो जाता है।



→ when two or more deposits have to be worked by U/g mining methods.

↓

① Staple pit (secondary shaft)

② Cross measure drift.

→ Staple pit / blind shaft → A verticle shaft from one U/g working place to another U/g working place but does not extend to the surfa

→ Cross measure drift → Also called drift or brevity. It may be horizontal/inclined. An U/g roadway for connecting Two or more coal seams.

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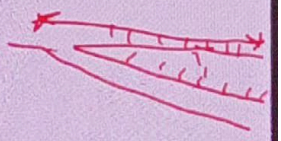
Shaft V/s Incline

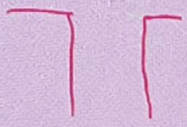
Shaft	Incline
→ Costly & time taking	→ Cheaper & quicker
→ headgear is costly & heavy Capital cost	→ Men can travel to the surface easily
→ winding arrangement required in case of breakdown it is not possible for men to travel to the surface	→ Mines बंद होने के case में ज्यादा manpower की जरूरत नहीं रहती।
→ Mines बंद होने के case में inspection or maintenance के लिए winding को तैयार ready रखना पड़ता है।	→ Much safer than shaft.
	→ Maintenance & repairs are cheaper & easy
→ It requires a no. of safety devices.	→ High prod.^{n} can be achieved by widening of incline.
→ Daily inspection required	→ Trackless mining by Conveyors.
→ To increase prod.^{n} shaft widening के कारण raising arrangement dislocate हो जाता है।	→ Locomotives को U/g में ले जा सकते हैं।

Disadvantages of incline

→ Heavy make of water in rainy season due to large area.

→ site selection out crop region तक ही limited होना चाहिए.



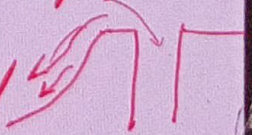


selecting site of an Incline or shaft.

→ The site should be above the HFL of a river or lake in the area.

→ sloping ground होना चाहिए away from the shaft.

→ shaft / incline should be situated close to efficient transport



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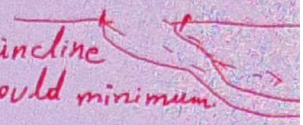
of a river or lake in the

→ sloping ground होना चाहिए away from the shaft.

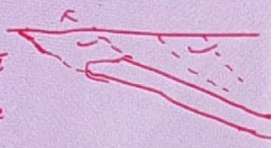
→ shaft / incline should be situated close to efficient transport



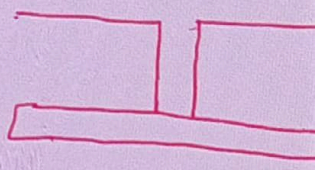
→ surface transport of mineral from incline or shaft to processing plant should minimum.

→ Broken ground like goaf area, stoped area & site near geological disturbances like faults, dykes & sills should be avoided.

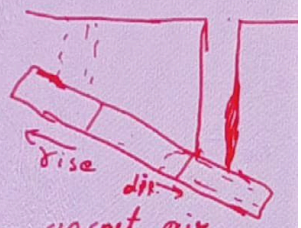
→ costly land should be avoided.



→ For a coal seam of moderate inclination the shaft may be in the middle.



→ where the seam has more inclination shaft should have 1/3 area on dip side & 2/3 on rise.



→ Shaft used for sand stowing pipes then shaft should be on the rise side.

→ Ventilation shafts used mainly for upcast air where exhaust fans are used is on rise side

→ If mine leasehold is not hilly and land is flat or uniformly sloping then prod.^{n} shaft is in the middle of mine area

→ for site selection of shafts pilot holes are drilled.

→ Trial pits → 3m to 5m deep.
↓
for testing bearing pressure strata

→ Incline in Coal seams.
↳ rope haulage → max.^{m} length 600m
↳ belt conveyors → max.^{m} length 1000m

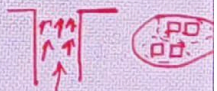
20:21 | 06:30 11.0 KB/s 4G 35

Shape, size & No. of shafts

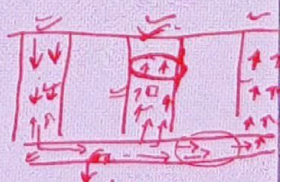
→ Shape → Circular or rectangular
→ finished dia → 4.2m to 6.7m.
→ Single cage shaft dia → 4.2m.
→ Tandem cage shaft dia → 5m to 6m.
→ Acc. to reg^n each seam should have at least two outlets to the surface.
→ Dist. b/w two outlets → 13.5m.
→ 2 shaft एक साथ sink किए जाते हैं जिनके बीच का separation 30 से 60m होगा।
→ जब तक दोनों shaft below ground में एक दूसरे से connect नहीं हो जाते हैं तब तक development start नहीं कर सकते।
→ एक shaft का use mineral winding के लिए किया जाता है।
→ दूसरा shaft → Vent^n, man-winding, material winding.

→ Passages are of Two types. (in case of shaft)
① Pass bye → walkable passage → To connect two outlets.
→ dimensions → 1.8m high
1.5m wide
→ Acc. to reg. 71
② by pass → for crossing the shaft belowground without entering the shaft
→ dimensions → 1.8m high, 1.2m wide Reg. 89

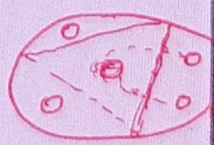
→ Upcast shafts में air locks लगे होते हैं जिससे थोड़ा बहुत Raising करके grade control. यह या तो अलग seam में होगा या फिर अलग level में होगा



→ 2 shafts के आस-पास होने के फायदे
① common → boiler plant, pit-top arrangement, screening plant, crusher plant siding.
② 2.5 km^2 के area में कम से कम shafts के 2 or more pairs होने चाहिए।



→ Geological disturbances के कारण area को zones में divide करते हैं। और हर एक Zone में एक shaft जरूरी है।



Depth of shaft

→ 5m below decking level → to accomodate cheese weight of guide ropes.
→ 2m below girder level
if guide ropes are ⊥ to the sinders

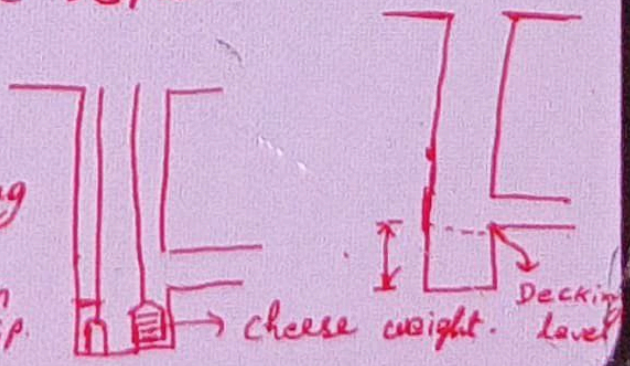
Depth of shaft.

→ 5m below decking level → to accomodate cheese weight of guide ropes.

→ 2m below girder level if guide ropes are attached to the girders

→ 6m below decking level → if skip winding is adopted

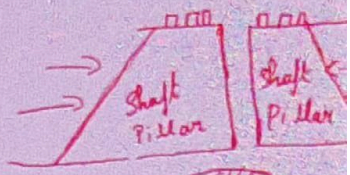
→ It depends on height of skip



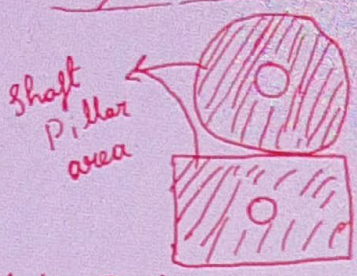
Shaft Pillar

→ In a mine a solid block of rock called shaft pillar should be kept on all sides of shaft and only essential rods should be driven through it.

→ Mines regulation में shaft Pillar के specific size के बारे में नहीं दिया है।



→ Need of shaft Pillar →
① Keeps the shaft intact.
② Surface structures को support करता है।



→ Thumb rule for size of shaft Pillar.

D = depth of shaft in m → seam
t = thickness of ~~shaft~~ in m
R = Radius of shaft Pillar in m.

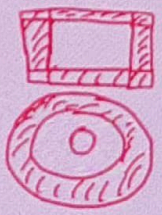
① Dron's Rule
Area of shaft pillar = Area to be supported + $\frac{D}{6}$ on all sides.

$90m^2 + \frac{\cancel{120}^{20}}{\cancel{6}_1}$
$110m^2$

② Foster's Rule
$R = 3\sqrt{Dt}$

③ Wadins Rule
For shafts upto 100m depth → not less than 36.5 × 36.5m
after that for every 36.5m depth increase size by 9m

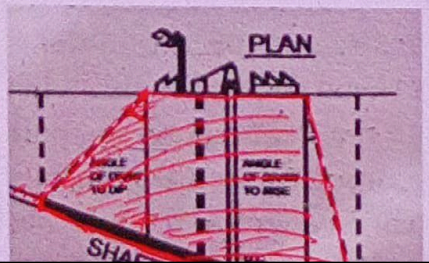
④ Mining Engineers rule.
for shallow shaft → Mimm radius of shaft Pillar is 18m.
for deeper shaft → $R = 18.3 + \frac{D\sqrt{t}}{32.8}$

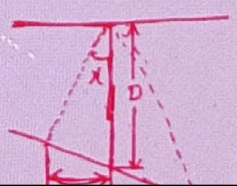


⑤ O' Donahue's formula for inclined seam.
D = depth of shaft.
x = angle of dip of coal seam
y = D sinx cosx

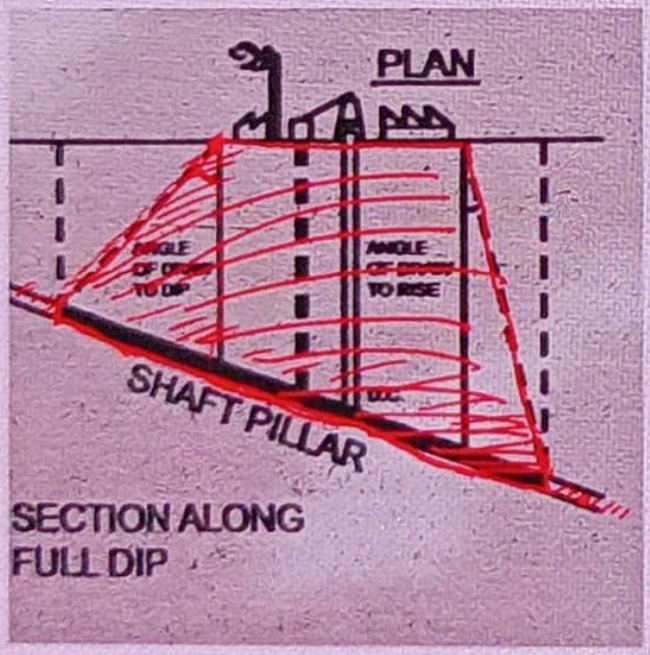
S = Margin of safety, Usually 5% to 10% of depth.

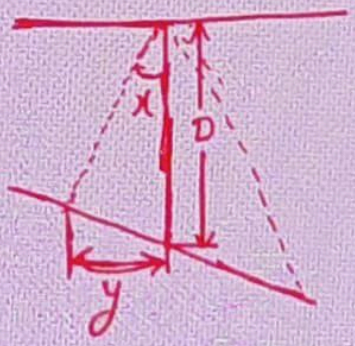
width of Pillar - on rise side = $S + D/7 + 2y/3$
dip side = $S + D/7 - y/3$
along strike = $S + D/7$





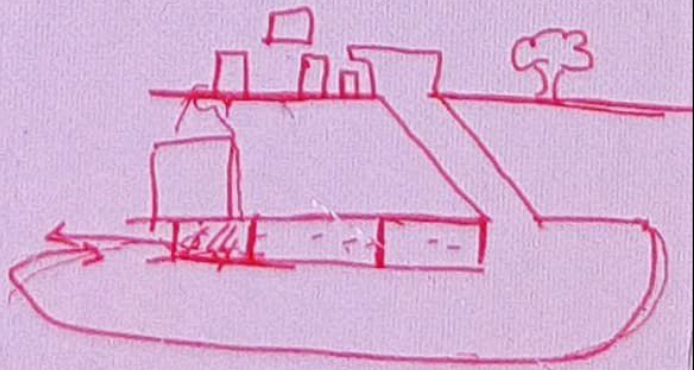
along strike = S + D/2





→ Shaft pillar का size calculate करने के लिए जो भी Scientific Approach करते हैं वह 'Angle of draw पर based होता है।

→ Incline के case में Coal mines को आधार B&P method से develop करते हैं तो Coal के 2 pillars को unextracted रहने देते हैं incline के दोनों side.



Pit-Top & Pit-Bottom Layouts

① Haulage incline Top Layout.

→ Tub capacity → 0.8 – 1.1 m^3

→ Capacity of layout → 600 tubs/day in 3 shifts.

→ Little mechanisation → manual labours used for tramming of tubs.

→ Set of tubs → 3 to 6 → It depends on gradient of track and HP of haulage engine

→ Loaded tubs lowered by gravity

→ Tipplers → T_1 → for screening plant, railway wagons & trucks.

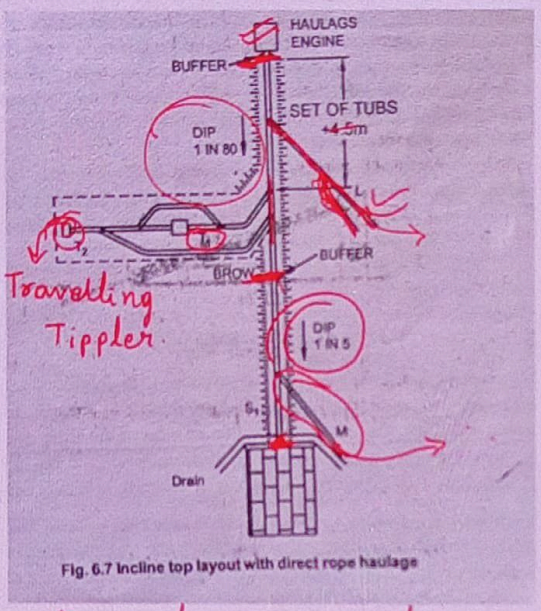
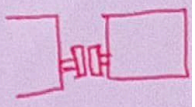


Fig. 6.7 Incline top layout with direct rope haulage



→ T_2 – for dumping yard.

→ Travelling tipplers also used for more dumping space.

Branch line L → for manual emptying
→ for standage of tubs temporarily out of use.

Track TM → to carry motors, pumps etc. to work shop.

Gradient → Buffer to inclinemouth → 1 in 5
→ Haulage engine to Buffer → 1 in 80

② Conveyor Incline Top Layout.

→ Main belt overhead bunker में discharge करता है

→ Main belt से एक छोटा सा belt जिसे Cross belt कहते हैं निकाला जाता है यह coal ground bunker में ले जाता है ताकि ground stock maintain कर सकें।

→ Ground stock में भी एक Bunker होता है जिसके bottom में Chute लगा होता है for

→ Ground stock में भी एक Bunker होता है जिसके bottom में chute लगा होता है for loading in railway wagons & trucks.

→ Ground bunker में coal को dozer की help से push करके डाला जाता है।

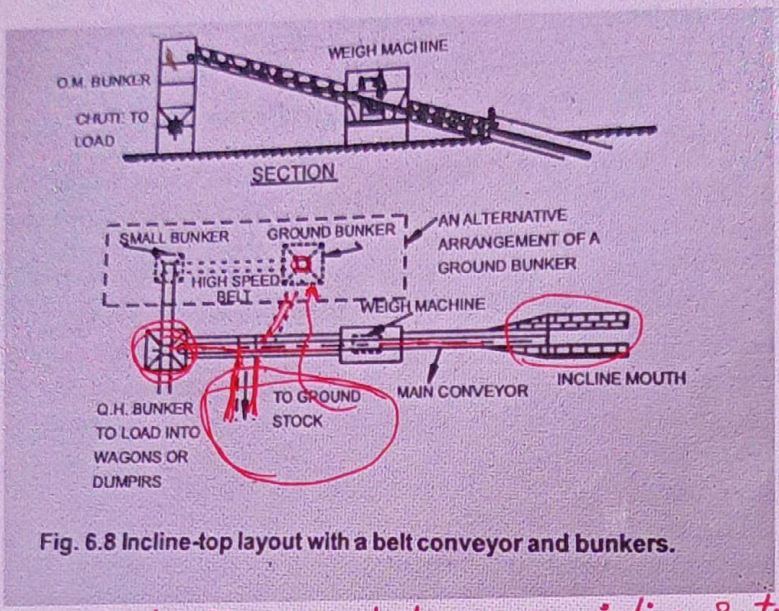


Fig. 6.8 Incline-top layout with a belt conveyor and bunkers.

Pit - Top Layout for Cage winding Pits.

→ Man - winding cages or skips से होता है।

→ Material winding के लिए single cage / tandem cage होता है।

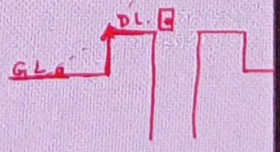
→ Mine Car → Tubs of Capacity more than 1.25 tonn

→ Raising capacity depends on shaft capacity & it depends on manner in which mine cars are handled at pit top & bottom

Objectives of pit top & bottom Layout design.

1. Use of shaft to its full capacity
2. Use min.m no. of tubs in circuit.
3. Use min.m no. of operatives.
4. Maintain steady flow of tubs.
5. Min.m decking time.
6. Lowering of materials.
7. Handling of different grades of ores or coal.

→ अगर discharging पास में रहेगा तो less no. of tubs की जरूरत रहेगी circuit में।



→ Mine Cars को long distances के case में Under gravity freely use नहीं करते हैं।

→ Mine Cars को long distances के case में under gravity freely use नहीं करते हैं।

Run - Around Arrangement.

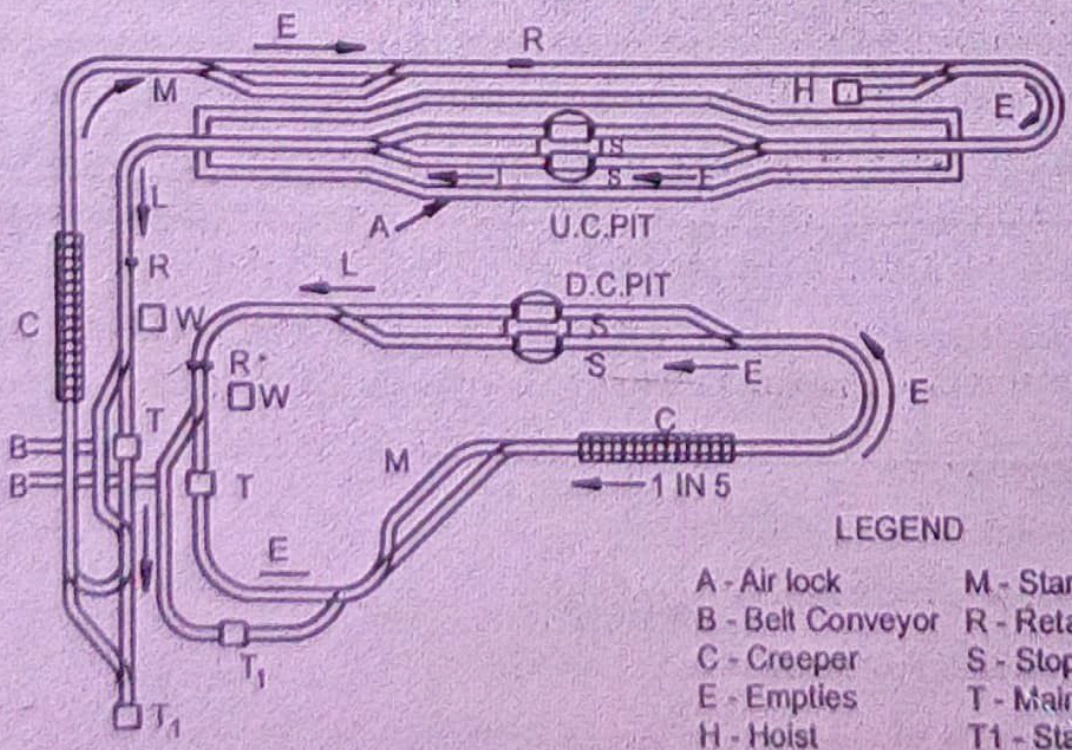


Fig. 6.9 Pit top layout with run-round arrangement

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Run - Around Arrangement

→ Loaded tub weighbridge (W) से tippler T में जाते हैं और empty tubs under gravity creeper में जाते हैं।

→ Creeper tubs को decking level से ऊपर elevate करता है।

→ Different quality of coal or seams के लिए Diff tipplers होते हैं।

→ Loaded tubs के लिए Creeper use नहीं करते हैं उसमें normally एक gantry (bridge for crane) से decking level को 4-6 m ऊपर रखा जाता है।

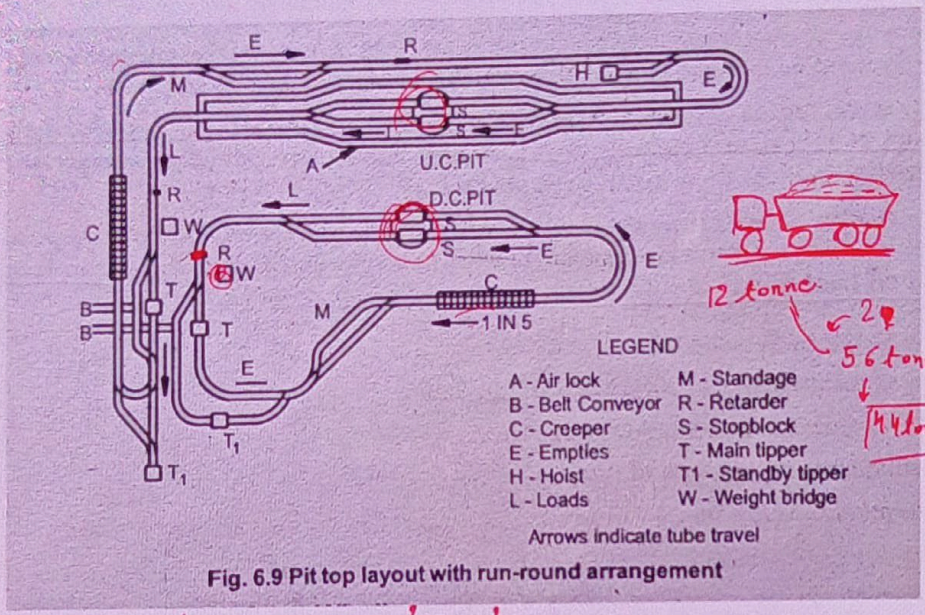


Fig. 6.9 Pit top layout with run-round arrangement

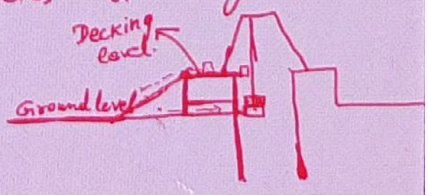
→ Two Tipplers use करते हैं
पहला Tippler → for shale or stone
2nd tippler → for coal.

→ अगर screening plant breakdown / stoppage हो जाता है तो पहले वाले tippler का use कर सकते हैं coal tubs के लिए।

→ Travelling tipplers can also be used for dumping in yards.

→ जब decking level ground level से ऊपर होते हैं। उसमें material को mines के अंदर ले कर जाना है

① तब shaft walling में एक opening बना कर tracks लगा देते हैं। tracks से cage में load कर सकते हैं।



② Material को decking level तक hoist करते हैं

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Disadvantages of Run-Around Arrangement

1. Large space required
2. Long Circuit
3. Large radius Curve

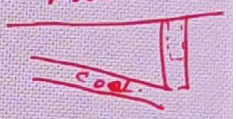
Pit-Bottom Layouts for Cage winding.

→ It depends on the type of transport system & method of winding.

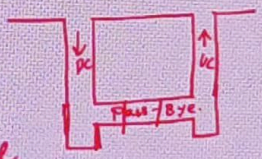
Rope Haulage Layout.

→ Coal winding सिर्फ एक ही level से किया जाता है इसके लिए decking arrangement coal seam में ही किया जाता है।

→ shaft को dip side में रखा जाता है और वह DC shaft होता है। और एक main coal winding shaft होता है।



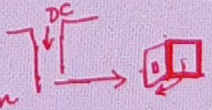
→ दोनों shafts को roadway से Connect किया जाता है और Air locks लगे होते हैं।



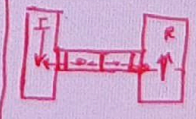
→ Lowering of materials from surface is done by UC shaft which has little output.

→ Air locks → 3 doors opening towards DC shaft against Air pressure.

→ 3rd door opposite direction में open होता है और emergency में Vent.n system को reverse करने में help करता है।



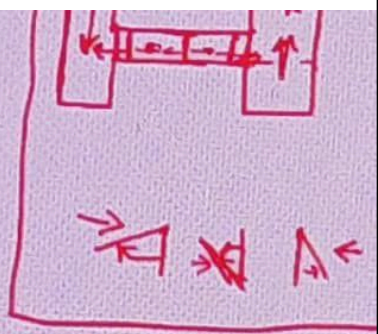
→ Dist b/w two doors → not less than longest timber or rail to be transported.



→ DC shaft में high Voltage cables होते हैं। UC shaft गर्म होने के कारण Power Cables के लिए use नहीं होता है।

→ Pit bottom Pump से delivery pipes DC/UC

longest timber or rail to be transported.



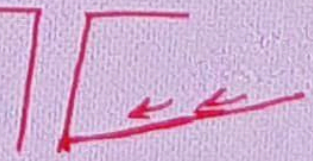
→ DC shaft में high Voltage cables होते हैं। UC shaft गर्म होने के कारण Power Cables के लिए use नहीं होता है।

→ Pit bottom pump से delivery pipes DC/U shaft से Surface पर ले जाते हैं।

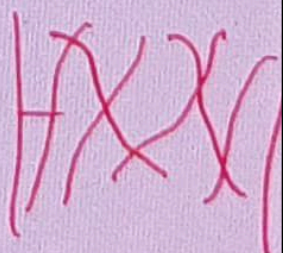
→ Tracks 1 in 80 to 1 in 120 के gradient के साथ shaft bottom की तरफ Dipping होते हैं।

→ Double tracks are used.

→ Diamond Crossing tracks होते हैं ताकि 2 से 4 tubs को clear space provide कर सके



→ 3rd track 10 to 15 m long for standage of material transporting trolleys.



Midset landing Arrangement

→ जब mineral को 2 या उससे अधिक seam से Raise करना होता है तब middle or intermediate seam से arrangement किया जाता है जिसे Midset landing landing arrangement भी कहते हैं।

→ Midset landing में fixed recievers use करने से better है Rigid guides use करना होता है।

→ The arrangements req. at midset landing if guide ropes are used.
① Hinged Platform
② Safety gates
③ stope blocks.

① Hinged Platform. → levers से manually operate होता है।
→ Platforms midset के दोनों Side से rods और link से connected होते हैं।
→ Platform bridge बनाता है midset और cage के बीच में।

② Safety gates → on each side of midset landing
→ sliding or collapsible type.
→ ये hinged platform से connected

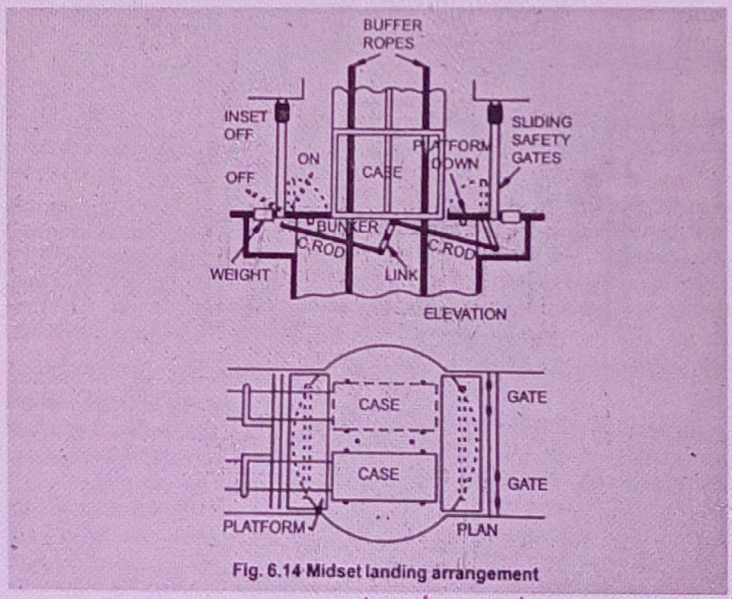


Fig. 6.14 Midset landing arrangement

stop blocks → to control tubs at midset.

→ Signalling system → Telephone.
→ separate/distinct code of signals use करें।
→ Red & green light signa

→ जब 2 seams या 2 levels एक ही shaft में चल रहे हों और दोनों का same

→ जब 2 seams या 2 levels एक ही shaft में चल रहे हो और दोनों का same output हैं तब winding arrangement इस तरह करना है की जब Cage midset पर हो तब दूसरा Cage Pit bottom decking level पर होना चाहि

→ Two drums of different dia

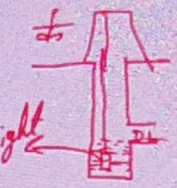
Sump

Drainage of shaft bottom & the main sump

→ Guide rope को tight रखने के लिए उसमें Cheeseweight लगाया जाता है। उसके bottom end में

→ इससिड shaft को 4.5m to 6m deeper रखा जाता है decking level.

→ shaft levels में water के overflow को रोकने और cheeseweight को पानी से free रखने के लिए shaft bottom से water drainage के arrangements किए जाते हैं।



→ इक pump shaft level पर लगा होता है। Pit bottom में suction pipe होता है, और वहा तक जाने के लिए ladder लगे होते हैं।

→ Method is applicable where pit bottom is only 3m to 5m below decking level.

→ Water drainage का सबसे best way है UC और DC shaft को sump से connect कर देते हैं।

→ UC और DC shaft short circuit ना हो इसके लिए UC shaft के bottom से stone में इक level gallery बनाते हैं और उसमें water seal arrangement करते हैं।

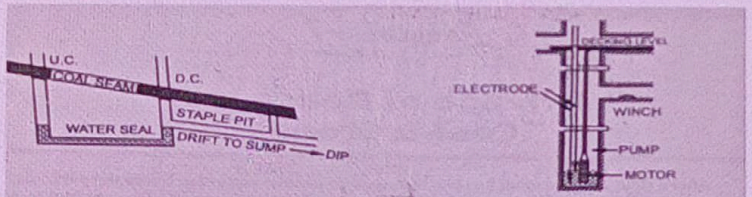
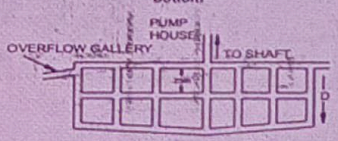


Fig. 6.15 Drainage of upcast and downcast

Fig. 6.16 Submersible borehole pump for shaft bottom



Above : Usual main sump arrangement at pit-bottom.
Below : A double sump with two walls.

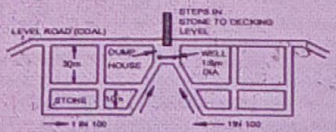
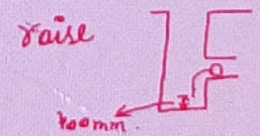


Fig. 6.17 Main sump arrangement

→ Submersible bore hole pumps का भी use कर सकते हैं। इसके bottom और pit bottom के बीच में कम से कम 400mm का clear space होना चाहिए।

→ Pump को winch की help से raise और lower किया जाता है।



→ Winch को decking level के नीचे इक drift बना कर install किया जाता है।

20:36 | 21:15 0.56 KB/s 4G 32

→ Winch को decking level के नीचे 100mm इक drift बना कर install किया जाता है।

→ Pump self priming होता है।

→ इसमें 3 electrodes लगे होते हैं अगर water level middle electrode से नीचे जाता है तो circuit break हो जाता है।

Main Sump

→ Pit bottom के dip side में होता है।

→ पूरी Mines का पानी सभी districts से main sump में collect होता है।

→ Essential features of main Sump.

① dipmost level gallery junction की तरफ dipping होना चाहिए ताकि water इक common point की तरफ flow करे।

② Pump के foot valve का junction में रखते हैं।

③ flat seam में junction में इक pit बना देते हैं → 1.8m dia × 1.2m deep.

④ Suction head 6m से ज्यादा नहीं होना चाहिए

⑤ अगर rainy season में pump fail हो जाता है तो sump में 24hr. तक water store करने की capacity होना चाहिए।

⑥ Overflow arrangement होना चाहिए जो की dip gallery से connected हो।

⑦ Pump house position → overflow के कारण pump पर कोई effect ना पड़े।

⑧ shaft से pump house तक tracks बिछे होने चाहिए for transport of pumps, motors pipes etc.

Main sump with Two wells.

→ जहाँ पर sand stowing method practice किया जाता है वहा पर Double sump arrangement mainly preffer होता है।

→ Sand stowing districts से water बहुत सारा sand ले कर जाता है।

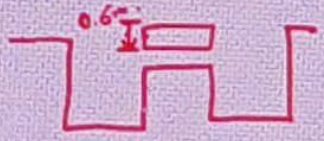
→ इसके कारण Main Sump का regular cleaning जरूरी हो जाता है।

1. additional sump, when one sump is

→ इसके कारण main sump का regular cleaning जरूरी हो जाता है।

→ Provide additional sump, when one sump is being cleaned.

→ Settling tank must be provided, where sand can settle down.



→ Depth of wells → 6m.
Dia of wells → 1.5m.

→ दोनों wells को top से 0.6m नीचे एक 200mm की Dia वाली Pipe से Connect करते हैं।

→ इस Connection से दोनों sump water share कर लेते हैं।

→ Pipe में sluice valve लगा होता है।

→ Overflow के case में पानी drift से भर जाता है।

→ wells में suction pipes लगे होते हैं

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Drivage of Roads in Coal & Stone

→ जिस Coal seam में काम करना है जब shaft उससे 2m नीचे चला जाता है तो Drivage बनाना start करते हैं।

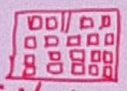
→ Shaft pillar limits तक coal का extraction नहीं करते हैं। सिर्फ drivage बनाया जाता है।

→ Use of drivage
1. Ventilation
2. Transport
3. Drainage
4. stowing
5. distribution of electric/compressed air Power

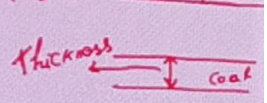
→ Main points of any mining activity.
1. safety & mining regulation.
2. Support of roof & sides & surface features.
3. Ventilation
4. Drainage
5. Transport.

→ Development → किसी भी mine में coal में roadway का drivage ताकि उनका network boundary तक पहुंच सके।

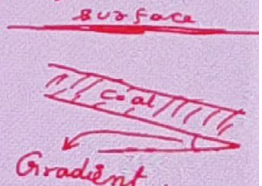
→ Boundary → It may be lease boundary of mine fault plane, dyke or any other artificial boundary



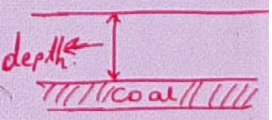
→ Types of coal seam on the basis of thickness
1. Thin seam → less than 1.5m.
2. Moderately thick seam → 1.5m to 4.5m.
3. Thick seam → 4.5m to 9m.
4. Very thick seam → beyond 9m.



→ Types of coal seam on the basis of gradient.
1. Flat seam → not more than 5°
2. Inclined seam → 5° to 18°
3. Steep seam → 18° to 40°
4. Very steep seam → beyond 40°



→ Types of Coal seam on the basis of depth
1. Shallow → below 200m.
2. Moderately deep → 200 m to 450m.
3. Deep → beyond 450m.



→ Types of Coal seams on the basis of degree of gassiness

	% of Inflammable gas in General Body of Air	Rate of emissio
Degree – 1 →	below 0.1%	below 1m³/tonn

→ Types of Coal seam on the basis of depth

① Shallow → below 200m.
② Moderately deep → 200 m to 450m.
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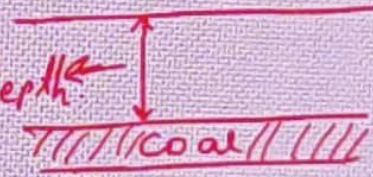


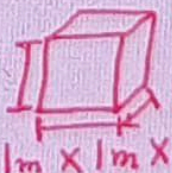
→ Types of Coal seams on the basis of degree of gassiness.

	% of inflammable gas in General Body of Air	Rate of emissio
Degree - 1 →	below 0.1%	below $1m^3$/tonne
Degree - 2	above 0.1%	$1m^3 - 10m^3$/tonn
Degree - 3		above $10m^3$/tonn

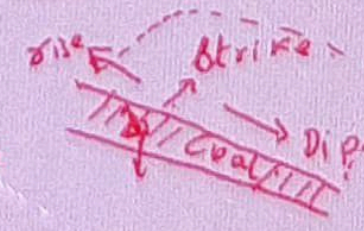
→ Gallery → A road in Coal seam.

→ Dip gallery / Dip → a road driven along dip of Coal seam.

→ Level gallery / Level → a road driven along strike of coal seam.

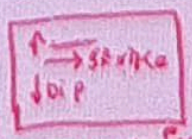


→ Stone gallery → One end of road is in Coal & the other end is blind end.



→ Drift → A roadway in stone connecting two or more coal seams.

→ Pillar → A solid block coal surrounded by galleries from all sides. It is a natural support to roof in a mine.



→ Crosscut → A gallery which cuts across the pillars due to its drivage along an apparent dip.

→ Heading → A gallery in the process of being driven.

→ Face → The moving front of any working place on the inbye end of any gallery, roadway or drift. A face in a coal is working place.

→ जब dip/rise heading का set drive किया जाता है तो उसके से एक heading को main dip/main rise कहते हैं।

→ बाकि के headings को companion dip/rise कहते हैं।

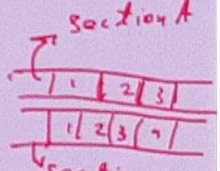
→ Main dip / Main rise में usually haulage or auxiliary fan arrangement होता है।

→ Main dip is equipped with face pump.

→ District → An area in a mine having a number of working places.

→ Panel → This word also used to denote district

→ यह बाकि के district से brick wall के artificial barrier or coal के natural barrier से separated होता है।



→ Cover → Vertical depth of a place in the mine from the surface.

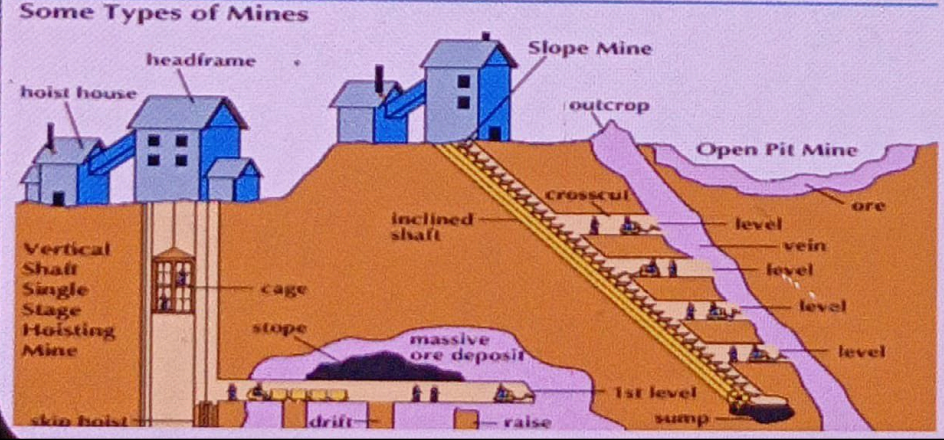
Metal Mining Terminology

→ Level → A level roadway in the ore body along the strike.

→ Crosscut → A level roadway from shaft passing through country rock.

→ Drive/Drift → A horizontal roadway ll to strike.

→ Cross drift / Cross drive → It is horizontal U/g roadway driven within ore body b/w HW&FW. It is at right angle to the drive/drift.



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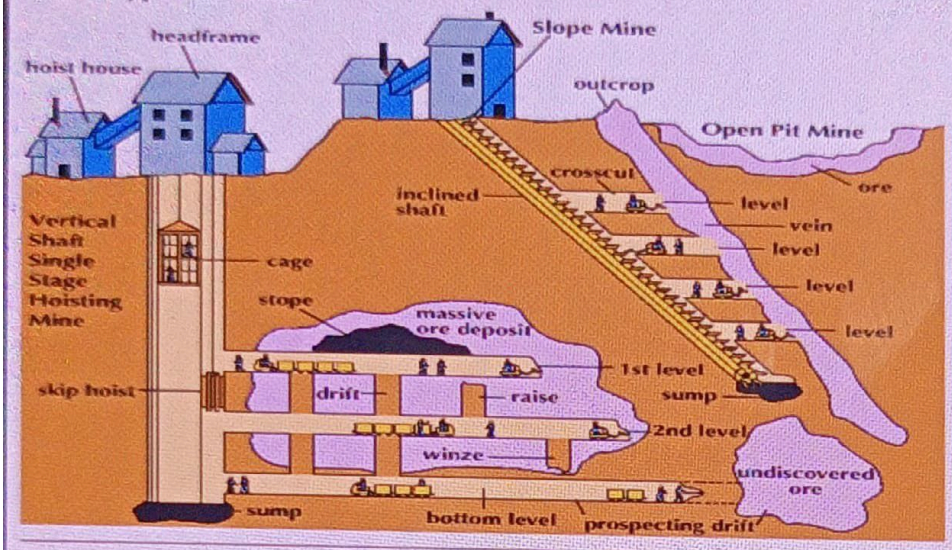


→ Reef drive → The drive is in vein itself.

→ Level interval → Vertical distance b/w two main levels.

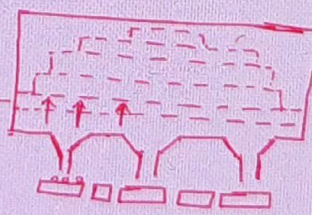
→ Sub level/Intermediate level → A level or dri b/w main levels/drive

→ Raise → A connection b/w two levels in an orebody driven in an upward direction.

→ Winze → A downward connection in the orebody b/w two levels.

Raise & winze are formed in footwall.

→ Ore chutes → Ore में से raises को जब upper level से lower stope level में अपने ही weight से जब Pass होने देते हैं।



→ Draw holes → short ore chutes

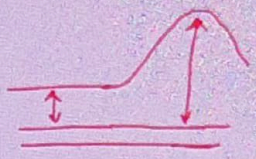
→ ore pass → Vertical/steeply inclined U/g passageway for downward movement of ore by gravity

→ Draw point → A spot on the floor from where gravity fed ore of a higher level is loaded into tubs or minecars.

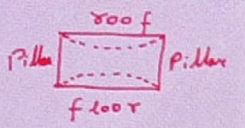
20:43 | 28:27 0.00 KB/s 4G 30

Size of Pillars & Galleries [Coal]

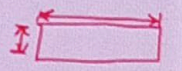
→ gallery width → 3m – 4.8m
→ gallery width → in case of CCM → 4m.
→ height → 2m to 3m
Acc. to reg → Max. width – 4.8m, Max. height – 3m
→ Travelling roads must be separate from haulage road
→ Height of travelling roadway → not less than 1.8m
→ Large pillar size कहाँ रखना चाहिए



① fault plane के पास
② where coal is soft & friable.
③ Near crushed zone
④ hilly areas because surface से depth naturally increase होता है।
⑤ जहाँ roof and floor चिपकते हैं या फिर heave करते हैं।
⑥ जहाँ development करने के बहुत समय के बाद De pillaring करते हैं।



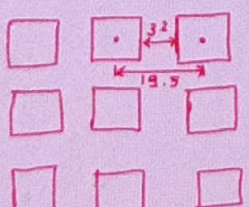
⑦ Steep seams में rectangular pillars होते हैं जिसमें longer side along the strike होता है।

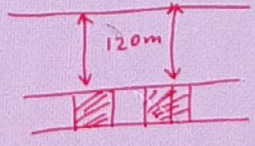


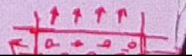
→ Galleries किस pattern में drive करेंगे यह Manager decide करता है।
→ Projection plan में यह चीज Manager के द्वारा mark किया जाता है।
→ Surveyor projection plan के basis पर Galleries के roof में Centre line mark करता है।
↓
daily / Alternate days → it depends on face advance

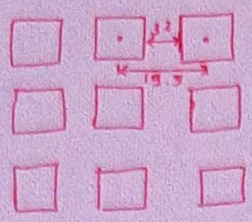
Depth of seam from surface	Where the width of the galleries does not exceed 3.0 m	Where the width of the galleries does not exceed 3.6m	Where the width of the galleries does not exceed 4.2 m	Where the width of the galleries does not exceed 4.8 m
	The distance between centres of adjacent pillars shall not be less than			
(1)	(2) metres	(3) metres	(4) metres	(5) metres
Not exceeding 60m	12.0	15.0	18.0	19.5
Exceeding 60 but not exceeding 90 m	13.5	16.5	19.5	21.0
Exceeding 90 but not exceeding 150 m	16.5	19.5	22.5	25.5
Exceeding 150 but not exceeding 240 m	22.5	25.5	30.5	34.5
Exceeding 240 but not exceeding 360m	28.5	34.5	39.5	45.0
Exceeding 360m	39.0	42.0	45.0	48.0

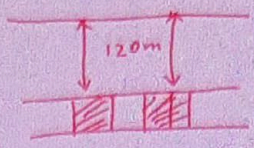
Gallery width → 3.2m
Seam depth → 120m
Centre to centre distance b/w adjacent pillars ⇒ 19.5m



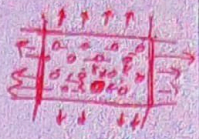






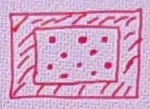


[Pillar width → 19.5 - 3.2 → 16.3 m]



Drivage of Galleries In Coal

① Mechanical Methods of drivage
- → Galleries are driven in sets of 3, 4 or 5
- → For Vent.n min.m 2 galleries is necessary
- → Machinery Used → Coal cutting Machine & Coal drill
- → face operations while using CCM
  - → CCM से cut मारना
  - → Shot holes drill करना
  - → Charging with explosives & blasting
  - → dressing roof & sides
  - → Loading of coal in tubs, mine cars & conveyors
  - → Dressing of sides, roof & floor to make face ready for next cut.



→ Blasting of solid or Solid blasting → P5 explosives are used

→ पहले B & P mining method में skid mounted CCM use होता था free face provide करने के लिए

→ Skid mounted machine coal pillar और haulage track के बीच में operate होता था।
इसके लिए 4m wide gallery, अगर 0.6m gauge के double track बिछाते है तो जरूरी था।

→ face pump का delivery जितना पास हो सके उतना रखना था; इसके लिए pump को iron के स्कूटलेग पर floor से 1.2m की height पर रखा जाता है।

→ Gate End Box (GEB) को level gallery के rise side में रखते है ताकि machine के rapid movement के कारण slip होने पर damage को avoid कर सके।

→ Length of trailing cables is limited to 100m

→ Electric coal drills → 1.25 HP के use होते है 2 workers hand से drilling करते है।
hole dia → 30mm hole depth - 1.1m to 1.5m

→ hole depth cut पर depend करता है at least 100mm कम होना चाहिए cut से।

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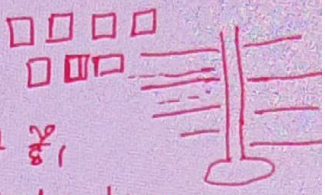
Support

→ Gallery drivage के time जो pillars बनते हैं उनसे naturally supported रहता है।

→ if roof is bad/weak → form less wide junct
→ level galleries in staggered pattern, main dip के दोनों sid

→ Props use नहीं करना है क्योंकि tubs के runaway के कारण props के dislocate होने का danger बना रहता है।



→ Thin seams में bar support के कारण gallery height कम होती है।

→ Roof bolting or Roof stitching is best option.

2) Drainage.

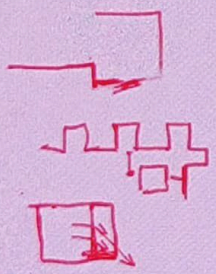
Types of pump on the basis of location of Installat

① Face Pump. → face sump
② Stage pump. → Stage sump
③ Main pump. → main sump.

→ Face pump → for dewatering dip faces.
→ Advances along with face.
→ 5HP to 15HP.
→ Head → 15 to 30m.
→ Mounted on pump trolley.

→ face sump → It is of temporary nature.
→ Small capacity
→ Serves one week. → where face adva
9m to 12m per week

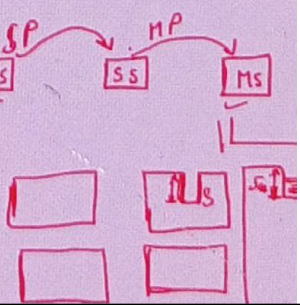
→ Thick seam → leave a ledge.
→ 0.4m to 0.6m high
→ on one side of gallery
→ 4.5m to 6m outbye of the face.



→ Thin seam → In the floor 2m×1.5m× deep
→ Capacity 2500 to 3000 lit

→ Stage pump → Discharges face sump water into stage sump.

→ Stage sump → formed by making short gallery of length 5m in a pillar.



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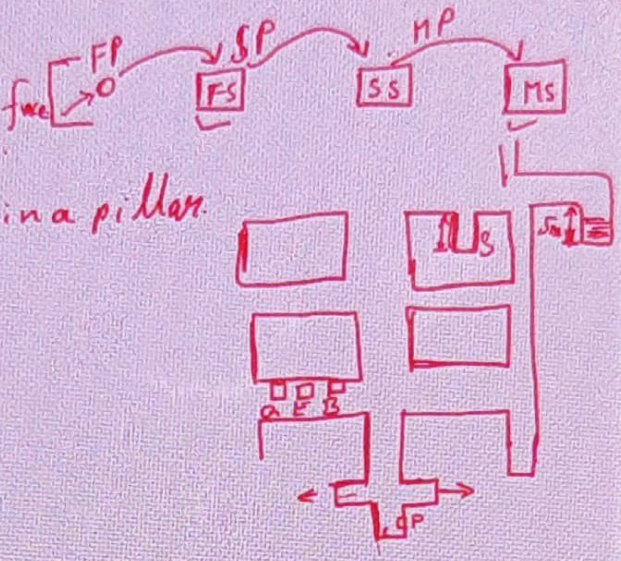


→ Main dip में water से deal करना एक बड़ी problem है। because companion dip को drive करने पर कुछ ही meter आगे बढ़ने पर heavy water bailing होता है।
जब main dip 3m advance करता है तब हर 3m के बाद companion galleries open कर देना चाहिए rise side.

③ Transport → Generally mines में mineral transport के लिए rope haulage, chain conveyors, belt conveyor & locomotives का use होता है।

→ for advancing face → Direct rope haulage
→ for rise headings → Tail rope haulage
→ for level headings → endless rope haulage
or
when distance is 1000 or more.
→ for shorter distances → hand tramming before haulage installations.

Progress of headings

→ water seepage के कारण Progress slow होता है। इसलिए level और rise galleries जो कि free from water होते हैं उन्हें drive करना चाहिए।

→ Generally 2 cuts by CCM per day main dip में सही रहता है।

Weekly Progress → 12m,
Monthly Progress → 48m.
Annual Progress → 300m in dip headings

→ Developing mines में main headings drive करना main target होता है। specially dip headings.

→ New mines में जहाँ railway sidings की facility नहीं है, main conc^{n} dip headings के drivage में होना चाहिए; Prod^{n} की जगह पर।

→ Normal Coal production रखने के लिए एक district 5-6 headings को along the strike रख सकते हैं।

→ जब arrangement हो जाए, strike के along districts open करके Prod^{n} को boost कर सकते हैं।

Ventilation.

→ Ventilating air का coursing working places में stopping, bratices or doors की help से किया जाता है।

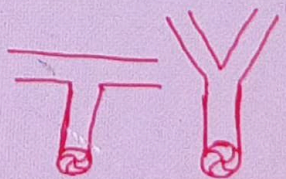
→ Bratices and doors को haulage roads में use नहीं करेंगे, क्योंकि workers उन्हें खुला छोड़ देते

→ Brattices से partition करने पर roadway की width कम हो जाती है जिससे tubs के movement और speed पर effect पड़ता है।

→ CCM & Coal loading में भी Problem होती है।

→ Auxiliary fan best होता है। जिससे air को duct or tube लगा कर coursing कर सकते हैं। T or V branches को tube से connect कर सकते हैं।

→ Tubes को roof से suspend कर दिया जाता है जो की long pegs पर supported होते हैं।



→ Auxiliary fan का installation इस तरह से होना

→ Auxiliary fan best होता है। जिससे air को duct or tube लगा कर coursing कर सकते है। T or V branches को tube से connect कर सकते है।

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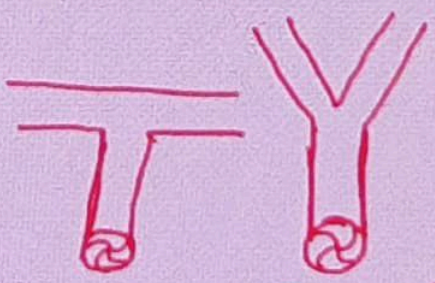

→ Auxiliary fan का installation इस तरह से होना चाहिए की air का recirculation ना होने पाए

→ heavy gassy mines में rise headings drive करना risky होता है, gas के कारण but level or dip galleries drive कर सकते है।

Drivage In stone [coal mines]

→ Drift drive करना stone में roadway कहलाता है

→ uses → ① access to shallow seams
② Passage from one seam to another
③ for transport
④ sand stowing.

→ Horizon mining में coal seams तक पहुँचने के लिए drifting जरूरी है। इससे development के समय costing को cut कर सकते हैं।
Manual drifting → 5 - 6 m per week } 10 m² cross sectio
Mechanized drifting → 100 - 120 m per week }

① Maintaining Gradient & direction of the Drift

→ जहाँ पर drift का drivage fault का throw पता करने के लिए किया जाता है ताकि seam तक पहुँच सके उस समय drift main haulage road के लिए use नहीं करेंगे।

→ इस बार fault पता लग जाता है तो drift की help से main haulage road का planning कर सकते हैं।

→ Surveyor permanent reference points drift के starting में ही roof में plugs की help से mark कर देता है

→ Reference points drift की centre line पर होना चाहिए। जैसे drift advance करेगा roof में हर 10m की distance पर master plugs fix किए जाते हैं।

→ Gradient line (Grade line) → red line
→ on the sides or on pillars.
→ 1m above floor of the drift.
↓
3m to 4.5m की distance पर plugs fix किए जाते हैं।

→ spirit level → To check grade line or gradient of floor.
↓
done by → Overman or drift incharge.

→ Checking of grade line and centre line by surveyor → at least once a week.
↓
by taking levels of the rail track

by taking levels of the rail track laid in the drift.

② Drilling → for soft sandstone or shale.
↓
1.25 HP, hand held, 110V.

→ Rotary coal drill भी use कर सकते हैं।

↓
① Replace gear box → drill rod की speed 600 rpm से 240 rpm करने के लिए।

② Diamond section drill rods के जगह पर turbine section drill rods use करना है।
↳ because diamond वाला जल्दी खराब होता है।

→ Coal के लिए जो drill bits use होते हैं इनका use soft stone में भी कर सकते हैं but इसकी life कम रहेगी।
↳ + 10 to 15 minutes में hot होने के कारण cool करने के लिए time देना पड़ेगा
↓
Nearly 15 holes in 8 hours.

→ Pull is only 1.2m to 1.5m.
↳ with one hand held drill
+
manual loading in tubs.

→ weekly progress → 5m for a drift of cross section 4m × 2m in 2 working shift.

→ hard sand stone में same arrangement कर सकते हैं But drilling slow रहेगी।
↓
More progress achieve करने के लिए power feed or mechanical feed arrangement best होता है।

→ hard strata में compressed air operated drills का use कर सकते हैं।
↓

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→ hard sand stone में same arrangement कर सकते हैं But drilling slow रहेगी।
↓
More progress achieve करने के लिए power feed or mechanical feed arrangement best होता है।

→ hard strata में compressed air operated drills का use कर सकते हैं।
↓
Penetration 0.2m to 0.3m per minute

→ Air legs fit कर सकते हैं इस से रिफी worker की safety improve होगी।
↓
rate of Penetration नहीं बढ़ेगा।
↓
Used for a drift of upto 2m height.

→ Large size drifts में Jumbo drills use करते हैं।
→ Jumbo drill के arms किसी भी angle पर drill कर सकते हैं। + यह portable होता है।
→ Stone drilling में burn cut or wedge cut pattern best होते हैं।

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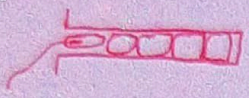
Blasting

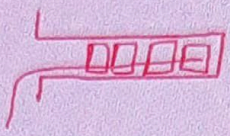
→ holes को charge करके एक साथ fire किया जाता है
↓
ms delay detonators are used because quantity of explosive is heavy

→ Inverse Initiation करके blasting करते हैं।

Direct



Inverse



→ Sumpers or centre holes को instantaneous detonators से connect किया जाता है।
↓
With delay upto 100ms.

→ Sand stone में 3.8 m × 3m Cross-section के drift में 10 to 12 kg explosive per metre advance पर consume होता है।

→ Avg drift of 10 - 11 m^2 cross-section area.
↳ 30 - 40 shots में total charge 18 - 22 Kg. for 1.5 m pull.

Mucking

→ Mucking means removal of blasted rock and cleaning the face.

→ Muck को old galleries में pack किया जाता है not in use.

→ जब face में tubs use करते हैं तो output 2 - 4 m^3 per shift per man होता है।

→ Double track arrangement use होता है।

→ Higher speed & lower cost achieve करने के लिए mechanical loading जरूरी रहता है।

→ Loaders → ① Slusher loader (scraper)
② Rocker shovel.

→ Slusher → Main & tail haulage mounted on wheels
एक side में ram or slide होता है और दूसरे side में Hopper होता है material को discharge करने के लिए।

→ Tail rope के लिए return pulley stone drift में।

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discharge

→ Tail rope के लिए return pulley stone drift के face में fix होता है।

→ Scraper V shape में होता है और top और bottom से open होता है → Capacity → 0.5 to 1.5 m³

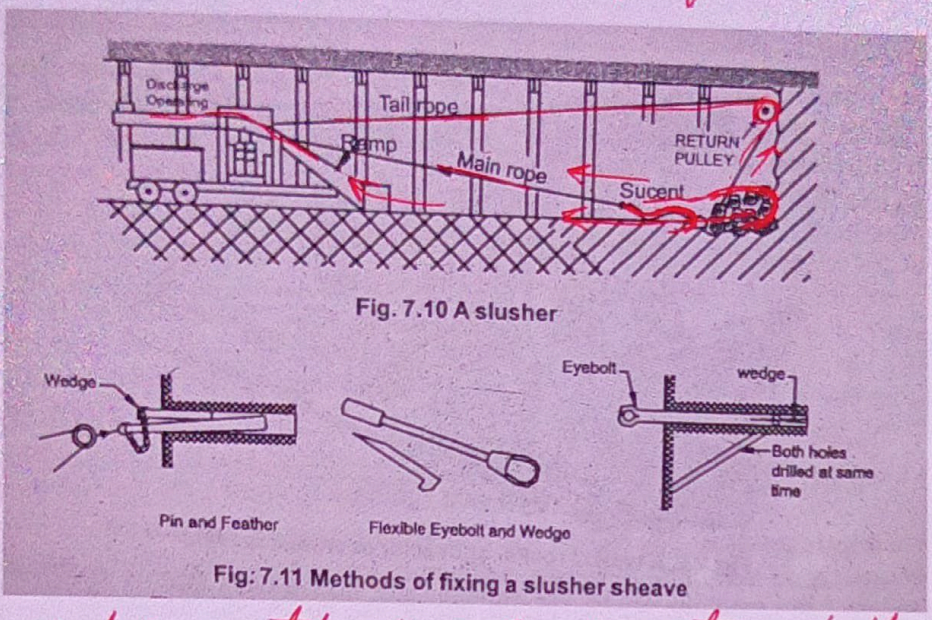

Fig. 7.10 A slusher

Fig: 7.11 Methods of fixing a slusher sheave

→ Used in metal mines & in stone drifts in coal mines.

→ Slushers को operation के समय rails से clamped रखा जाता है।

→ Capacity of slusher → 30 - 40 tonne per hour.

↓

Gradient → 1 in 3 & even steeper

↓

but not in soft rocks.

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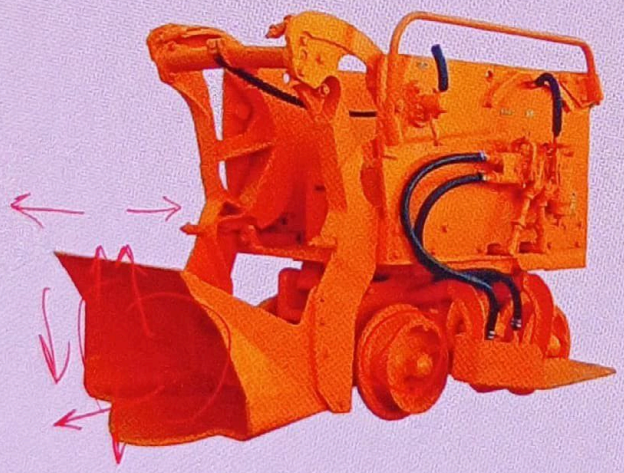
→ Rocker shovel → compressed air powered bucket होता है to push muck

- bucket material को upward & over motion से tub में discharge कर देता है।
  ↓ or Conveyor behind loader
- Mounting → Crawler, pneumatic tyres, wheels ↓ to travel on rails.
- Crawler mounted best of dipping drift max.m gradient 1 in 4



→ Raising gallery में tyred mounted में steep grade में loaded होते पर braking or control problem. होता है, इसलिए Crawler mounted is preferred.

→ Remote Controlled mucking machines
↓
Cavo 511 by Atlas Copco
↓
operates 4-6m from chutes

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Ventilation

→ Drifting is costly in coal than drivage of road

→ Ventilation in drifting → Auxiliary fan
↓
forcing or exhaust.

→ Upto 300 m length → Single fan is sufficient
↓
Recirculation avoid करने के लिए fan को main ventilating air current के रास्ते में install करते हैं
Drift के nearest corner से कम से कम 5m दूर।

→ In Long drifts → for efficient Vent.ⁿ & speedy removal of fumes after blasting

- Combination of exhaust & forcing fan is used
- Mouth of exhaust tube within 2m of face.
- forcing fan at least 10m away from outbye of exhaust tube to avoid recirculation

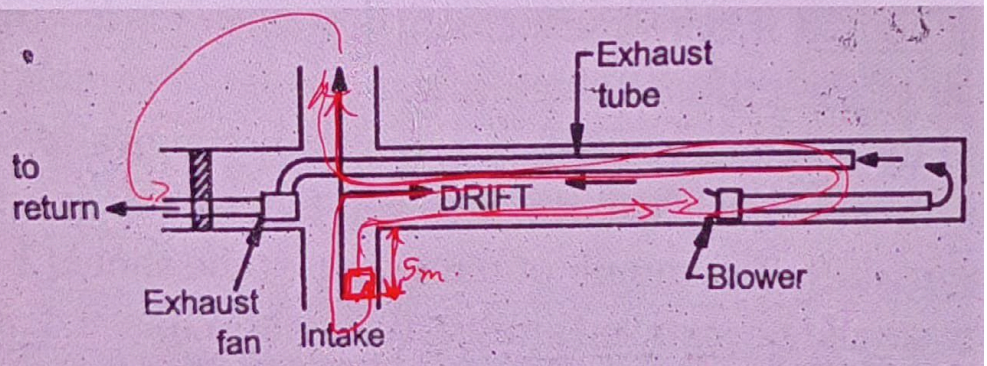

Fig. 7.12 Ventilation arrangement in a long stone drift

→ Diesel engines वाला use करते हैं तो at least 200 m³/min for a drift of size 4.2m × 2m air quantity होनी चाहिए।

→ वाला Jumbo drill use होता है तो 42 m³/min per drill

→ If compressed air machines used 0.175 m³/s

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Drifting At a Modern Colliery

→ Sudamdih Colliery → heavy drifting due to horizon mining system.

→ 12.5 Km road
→ excavated area - 4.8 m × 3.5m
→ Completed area - 4.3m × 3.1m.
→ Principle of working → All men of all jobs
→ 4.2 m wide drift में प्रति एक shift में 8 workers की एक team सारे काम manage करती है।
→ Drilling, mucking, blasting, setting of supports, extension of tracks, Ventilation, Compressed air pipes trailing cables etc.

Drilling

→ Two air leg mounted jack hammers
→ one drill reserve & one in maintenance
→ weight → 25 Kg
→ Air consumption → 2.8 m³ per minute at 6 Kg/cm
→ Air leg weight → 22 Kg.
→ feed length → 1300 m m.
→ Flexible hose dia → for air → 25 mm
for water → 19 mm.
→ Hexagonal drill steels → dia → 22mm
length → 1.6m.
Life → 800 m to 600m.
→ 4 workers operated 2 drills
↓
50 holes of 1.5m each in wedge pattern.

Charging, stemming & firing.

- 150g cartridge of Ajax - G.
→ Delay detonators
→ All holes fired in single round by multishot explod

→ Overhead type mechanical loader was used to unload in tubs 1 m³ capacity.
→ Empties के लिए tugger haulage use करते हैं।
→ Mechanical loader → Compressed air operated.
→ 5 m³ of air / min.
→ Compressor installed at surfa

flange pipe → dia - 150mm.
→ length → 6m.

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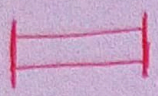
→ Compressor installed at surfa



flange pipe → dia – 150mm
→ length → 6m

Support
→ Concrete block lining
→ roof support → steel arches
In two segments
foot plate welded in each segment
(160 mm × 160mm × 10mm)
Two segments joined by fish plate.

Ventilation.
→ axial flow type auxiliary fan
→ Capacity → 270 m^3/min
→ Power consumption → 7 KW.
→ Fans were installed in series at 100 m intervals
→ Ventilating duct → 1.5mm thick.
→ MS sheets
→ 580mm dia
→ Length → 3m.

OVERALL CYCLE TIME
→ Crew of 8 to complete one cycle of 1.4m advance was 17 hours.

LASER RAYS FOR DRIFT DRIVAGE.
→ 2 target plates होते हैं।

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LASER RAYS FOR DRIFT DRIVAGE.

→ 2 target plates होते हैं।

→ 1st target plate → Cross marks, no hole

→ 2nd target plate → Cross marks, a hole in the cent

→ Instrument को roof bolts or drift के walls में fix किया जाता है।

→ Theodolite से alignment and gradient मिलने पर starting में 10m drift drive किया जाता है। उसके बाद laser system को fix किया जाता है।

→ Drift में theodolite के telescope की height laser system के height के बराबर होती है। और उसे fix किया जाता है।

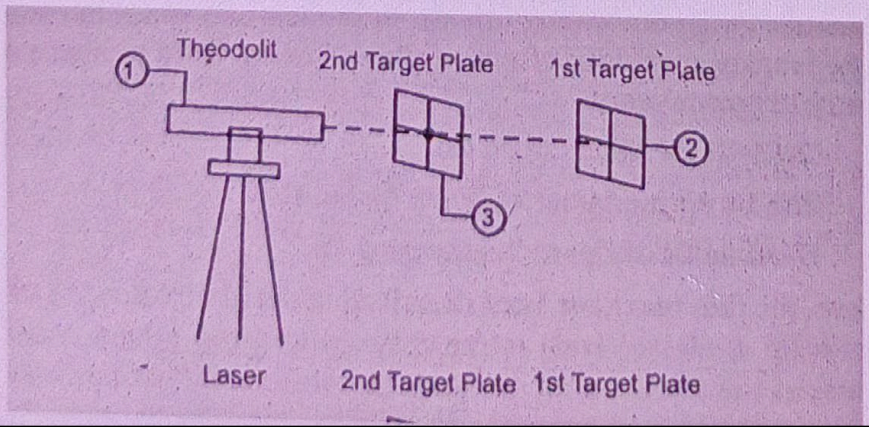
→ उसके बाद target plates को fix किया जाता है। 2nd target plate को 1st target plate और theodolite के बीच fix करते हैं।

→ इस तरह से fix करना है कि theodolite का Cross hair, 2nd target plate का hole & 1st target plate का centre एक ही line में रहे

→ अब theodolite को laser instrument से replace कर दो।

→ Laser को switch ON करके Red laser beam को adjust करो।

→ Drift के advance के साथ 1st target plate को shift करते रहते हैं।



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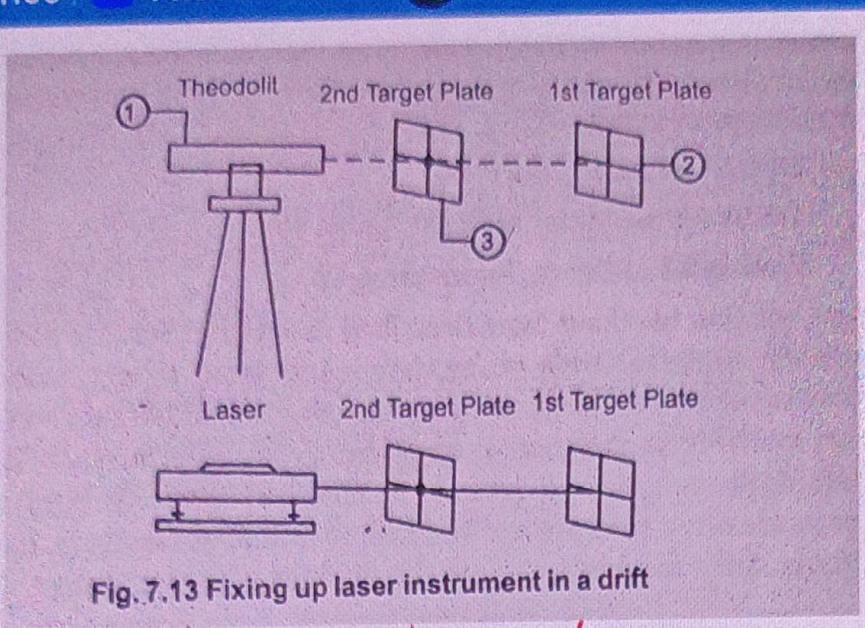


Fig. 7.13 Fixing up laser instrument in a drift

Tunneling & Road heading Machine.

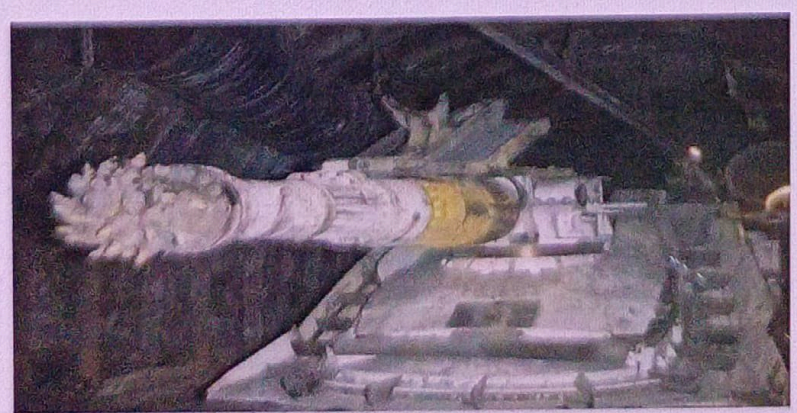
In seam drivage → suitable for all types of heading machines.

In deep mines → where arched supports are use
→ Suitable for heading machine with a boom.

∩

→ Road header MK 2A
→ A medium duty machine
→ weight → 23 te
→ Boom has axial rotating cutting headin

→ Roadheader MK 3A → A heavy duty machine.
→ 150 KW Power
→ Avg progress in 5 days - 70



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→ Boom has axial rotating cutting

→ Roadheader MK 3A → A heavy duty machine.
→ 150 KW Power
→ Avg Progress in 5 days - 70m

→ Dint header
→ weight → 16 te.
→ A lighter machine.
→ It has a cutting jib 1.72m wide.
→ Hydraulic operated.
→ working speed → 0.03 m/s.
→ fitting speed → 0.14 m/s.

Explosives, Accessories, & Blasting

→ Used in U/g mines & quarries to break coal & other rocks.

→ Explosive एक solid or liquid substance or mixture of substances जो chemical reaction होने पर large volume of gas high temperature & Pressure के साथ release करते हैं। जब flame, heat or sudden shock apply करते हैं।

→ High pressure के कारण rock break होता है।

→ Detonation → यह एक ऐसी process है जिसमें की explosive को violent shock दे कर ignite करते हैं।

→ Chemical reaction in explosive is an oxidation reaction.

→ Materials in explosive.

① Combustible matter → wood, fibre, sulphur, charcoal

② Oxidising agents → Sodium Nitrate, Ammonium Nitrate Potassium Nitrate.

③ Stabilizers → Magnesium & Calcium carbonate.

④ Antisetting agents → To prevent caking.

⑤ Sensitizers → Metallic powders.

→ Properties of explosive.

① Strength → Amount of energy released by an explosive.

→ ICI used term weight strength.

→ Weight strength → weight of explosive को same weight of gelatine से Compare किया जाता है

→ Gelatine को standard माना जाता है जिसका weight strength 100 है।

② Velocity of detonation (VOD)

→ It is the rate at which shock waves pass in explosive column.

→ Shock energy of detonation velocity ज्यादा होने पर increase करता है।

→ Explosives used in mines → VOD → 2500 m/s to 5000 m/s

High explosive, Permitted, Slurry

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→ Shock energy of detonation velocity ज्यादा होने पर increase करता है।

→ Explosives used in mines → VOD → 2500 m/s to 5000 m/s
High explosive, Permitted, Slurry

→ High explosives used as boosters → VOD → 6000 m/s
OCG Primer → 7000 m/s

→ Principle of VOD → Contact b/w Oxidizer & fuel
जितना intimate mixture होगा उतना high VOD होगा।

③ Density
→ High density explosive → energy is concentrated
→ Tunnelling, mining operation in hard ground
→ Low density explosive → energy gets distributed along the shot hole.
→ lump of coal is desired.

④ Water Resistance → for wet conditions
↓
Gelatinous or Slurry explosive
→ Nitroglycerine जितना ज्यादा होगा explosive में उतना water resistant होगा।

⑤ Sensitivity → Normal handling में explosive insensitive होना → Shock, friction
→ Sufficient sensitive to be detonated

⑥ Fume characteristics → Limited ventilation वाली जगह में ऐसे explosives use करें जो min.m harmful gases produce करते हैं।
Slurry or AN based explosives → better than NG.

⑦ Legal Permission → U/g Coal mines में permitted explosives का use करें।

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Types of Explosive

→ on the basis of speed with which explosive effect produced

① Low Explosive → Gun Powder

② High Explosive → AN, NG, TNT, special gelatine slurry explosive

→ Low explosives में blast करने पर oxidation होता है and particle to particle combustion होता है।

Ignition → flame

Ingredients are not explosive in itself

→ High explosive → Ingredients are explosive itself
→ explodes with violent shock.
→ fire → detonators
→ oxidation does not occur particle to particle
→ Give shattering effect.

→ Gun Powder → Charcoal, sulphur, Potassium Nitrat
(15%) (10%) (75%)
→ All these are not explosive by itself
→ Cheap, stable, safe to handle.
→ shows heaving effect.
→ Long duration flame is produced
→ firing → Safety fuse

Constituents of high explosive

① Nitroglycerine → Oily fluid
→ Sp. gr. → 1.6
→ freezing point 13°C
→ Insoluble in water
→ Very sensitive to shock.
→ Sensitivity increases with freezing.
→ absorbed by inert material to make it suitable for use.
→ Gelatinous, semi-gelatinous, powdery
→ Explosives having NG have high shattering effect
→ It produces fumes → headache.
→ Explosives having NG freeze at 8°C

21:04 | 49:33 0.00 KB/s 4G 26

→ It produces fumes → headache.
→ Explosives having NG freeze at 8°C or low → Sensitivity increases
→ To avoid this Low freezing agent is added - Di-Nitro-glycol

② Ammonium Nitrate (NH_4NO_3) → white hygroscopic salt
→ soluble in water
→ safe to handle.

→ High explosive
→ Oxidising agent
→ Cooling agent.

It is made by reaction b/w Ammonia gas & Nitric Acid.

$2NH_4NO_3 \rightarrow 4H_2O + O_2 + N_2$ (346 Kcal/gm)

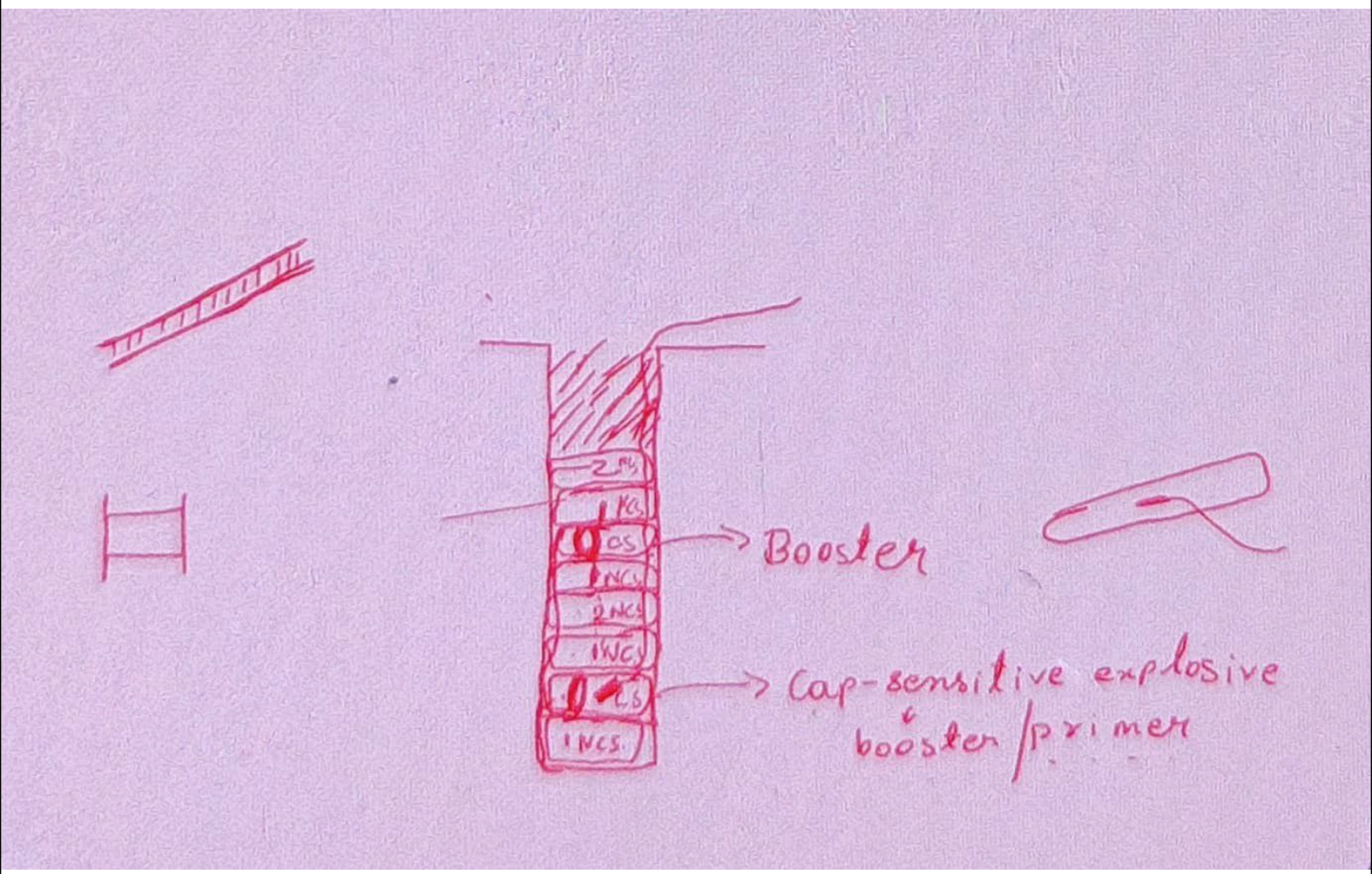
→ Cannot be detonated by detonator
→ Detonated by booster
→ AN को explosive के form में use करने के लिए उसे diesel oil, NG or TNT के साथ mix किया जाता है।

③ Collodion Cotton → It is made by reaction b/w Cellulose compounds & Nitric acid.
→ High explosive.
→ highly flammable solution

④ TNT → Trinitrotoluene.
→ Reaction b/w Nitric acid & benzene.
→ High explosive.

→ Explosive blasted by detonator are called cap-sensitive explosive.
To ignite → detonator ← Detonating fuse

→ Cap-sensitive explosive को booster or primer के नाम से भी जाना जाता है।
→ Non-Cap-sensitive → Detonated by cap sensitive explosive.
→ Also known as booster sensitive


2NCS
1CS
QS
1NCS
2NCS
1NCS
1CS
1NCS
Booster
Cap-sensitive explosive
booster / primer

Booster

→ Slurry explosive & ANFO mixture को detonate करने के लिए high detonation velocity वाले booster का use करते हैं।

→ PRIMEX → Mixture PETN & TNT
→ Water resistant
→ VoD → 7000 m/s
→ weight strength → 82
→ Detonated by DF & Detonator.

→ Pentolite → sp gr. → 1.55 to 1.61

→ Primex में cylindrical pellets होते हैं 2 holes के साथ ताकि DF की down line threading कर सकें।

→ इसके साथ slurry cartridge को insert कर सकते हैं

→ Cast Booster को large size के Powerful detonato से compare कर सकते हैं।

→ O/C mines में deep large dia blast holes में prefer किया जाता है।

→ Cast booster को DF के साथ knot करके उसे blast hole के bottom में रखा जाता है।

→ Booster को lower करने के बाद AN based site mixed slurry को Pump किया जाता है।

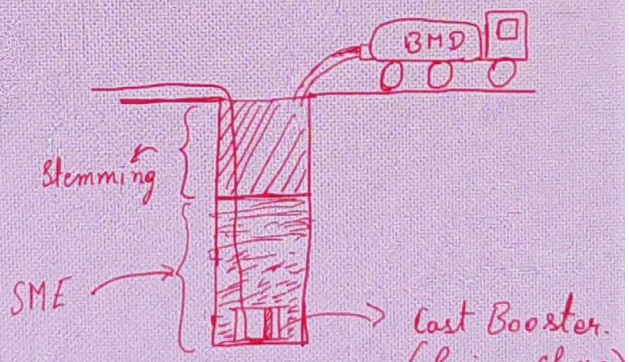
Cast booster

→ Front View

→ Top View

→ Knot DF

→ Detonator



Booster / Primer Explosives → Gelatinous NG-based
→ OCG
→ Special Gelatine

Do not contain NG ← { → Pentolite → IDL
→ PRIMEX → ICI

21:07 52:33 0.00 KB/s 4G 25

ANFO → Ammonium Nitrate fuel oil

→ AN को diesel oil के साथ mix करके o/c coal or metal mines में use किया जाता है।

→ Effective & Oxygen balanced mixture → 5 to 6% diesel oil (by w

→ Sp gr → 0.8 to 1.0

→ wt. strength → 75 - 80

→ VOD → 3500 m/sec.

→ Dry season → In 100 Kg AN → 7 litre

→ wet season → In 100 Kg AN → 9 litre.

→ अगर Diesel oil 8% से ज्यादा हुआ तो ANFO की initiating, sensitivity कम हो जाती

→ Safety → Gum boots & hand gloves.

→ AN should be kept packed in bags. (To avoid moisture)

→ Diesel oil.

→ No smoking nearby it.

→ No naked light or fire within 15m.

DGMS Circular & Reg-193 of CMR 2017

→ High liquid hydrocarbons को Diesel से higher quality के है उनका use नहीं करेंगे।

→ Most sensitive mixture → AN contains 2% Diesel oil

→ Excess oil should be avoid → because sensitivity decreases above 10%

→ Maximum → 5 - 6% mixture

→ No Person will smoke.

→ Mixing, charging or handling of explosive → No fire within 15m.

→ Mixing place के within 15m no combustible materia (dry grass)

→ जितनी quantity immediately use करना है उतना ही mixture prepare करें।

→ Mixing work → Near shothole.

→ In Portable wooden box

→ Mixing work → Near shothole.
→ In Portable wooden box.
→ Size for mixing upto 100 kg.
→ Dimensions → 1.5m x 1.0m x 0.5m
↓ depth
→ wooden shovels & no metallic Shovel

→ जिस building में AN bulk में stored है वहाँ mixing नहीं करना है।

21:09 | 54:28 0.12 KB/s VoLTE 4G 25

Bulk Mixing Delivery System

→ Bulk mixing & delivery, licensed vehicle में ही होना चाहिए → by chief controller of explosives

→ Mixing, loading & charging का operation, technical service engineer की guidance में होना चाहिए

→ shall be driven by competent licensed driver

→ Loaded vehicle को isolation में खड़ा रखना है।

→ Within 60m radius of vehicle → No flame or smoki

→ Within radius of 15m of vehicle → No Combustible matte

→ Prepared mixture को wooden box में ही Carry करेंगे metallic container में नहीं।

→ Minimum no. of persons shall be present within 15m of mixing site

→ ANFO mixed site की cap sensitivity regular intervals में test होना चाहिए

Testing → Detonator को ANFO के cartridge में डालकर isolated area में Soft ground में रख कर shotfirer blast करेगा। Ground में Crater Cap-sensitivity indicate करता है mixture का।

Charging & firing

→ After mixing ANFO, as soon as possible charge & blas

→ In dry holes pour freely & In wet holes pack in polyethylene bags before pouring.

→ In free pouring use funnel of wood or fire.

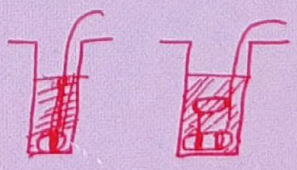
→ DF can be used for initiating 1 or 1

↓ High explosive primer cartridge → equal to 5 to 25 % of total charge.

Booster charges shall be of non-Nitroglycerine type.

→ Hole dia → less than 0.1m → DF की एक ही line use करेंगे

→ Before entering to blast area overman / shotfirer will do examination for reddish brown fumes & NO_2 gas

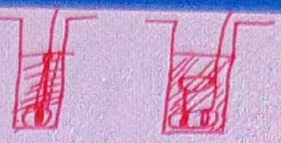


Fighting Fires Involving Explosives

... ANFO ... at same place or

21:10 | 55:01 66.9 KB/s 4G 25

overman / shotfirer will do examination for reddish brown fumes & NO_2 gas



Fighting Fires Involving Explosives

→ If high explosive & AN or ANFO are at some place or building and आग लगी हुई है।
1st attempt → Remove explosive from danger area.
If not possible → evacuate entire area & आग को जलने दें।

U/g Applications

→ ANFO should not be used in U/g coal mines.

Hazard of static electric.

→ Small dia holes में अगर pneumatic loading & charging किया जाता है।
→ Hose pipes → semi conductive material का होना चाहिए ताकि static current discharge भी हो जाए और current भी flow ना हो।
→ Resistance of semi-conductive material per 0.3m length Not less than 5000 ohm / 5000 Ω
→ Total length में 2 mega ohms से कम नहीं होना चाहिए।

Supervision

→ Competent person → holding Mgr, Foremans / Overm Certificate
→ Appointed by Mgr. in writing

Economic

→ 62 mm dia holes & above ANFO के लिए economic consider किया जाता है।
→ Blast hole dia 300 mm से ज्यादा होने पर initiation sensitivity कम हो जाती है।
→ ANFO में 4% से above water होने पर detonation decrease करता है।
→ ANFO में 9% से above water होने पर detonate नहीं कर सकते हैं।

21:11 55:53 0.00 KB/s 4G 25

Slurry explosive

→ Water gel → Oxidiser & fuel sensitiser का mixture होता है।
→ For thickening → gum
→ Gelling → Cross-linking agent
→ In case of permitted explosive coolant is added.

→ Ingredients
Oxidisers → Ammonium, Sodium or Calcium Nitrate
Cross linking agents → Potassium or Sodium dichromate antimony or boron compounds
Gelling agents → Starch
Fuel Sensitisers → TNT, PETN, pentolite (Explosives)
→ Aluminium, sugar, urea, paraffin hexamine, ethylene glycol, wood pulp (non-explosive)

→ Sp. gravity → more than 1
→ Can be used in U/g coal mines but must be capsensitive.
→ Highly water resistant
→ अगर slurry को direct pump करते हैं तो उसका blast holes के walls से अच्छा contact maintain होता है जिससे अच्छा result मिलता है।

→ Packaged 15% less effective होता है।
→ Pumpable slurries को strata condition के basis पर change कर सकते हैं।

SMS - Site Mixed Slurry

→ इसमें non-explosive ingredients को warehouse में store करके रखते हैं and transport करते हैं।
→ Semi-gelled Cond^n में SMS को truck में 2 week तक store करके रख सकते हैं।
→ Slurry को manufacture के time उसमें Cross-linking किया जाता है।

→ Charging के time additional Cross linking agents add किए जाते हैं। Explosive flow करके cracks & fissures में जा चला जाए।
→ SMS system में एक pump truck से nearly 25000 Kgf एक shift में charge कर सकते हैं।
→ 5-6 trained persons 50K - 60K Kgf explosive single working shift में charge कर सकते हैं।

25000 Kgf एक shift में charge कर सकते हैं।

→ 5-6 trained persons 50K - 60K Kgf explosive single working shift में charge कर सकते हैं।

→ IDL's Permitted slurry Explosive
AN, water, sugar, Aluminium (as fuel sensitisers), Sodium Chloride, Sodium Nitrate & gum.

→ Slurry explosive accidentally drop करने पर or shovel impact से explode नहीं करता है।
Even in fire कोई effect नहीं पड़ेगा।

→ Slurry explosives में low toxic fumes होने के कारण headache नहीं होता है।

→ NG based explosives, spark or vident shock के कारण ignite हो सकते।

→ Shelf life of slurry explosive → 1 year.

→ for best performance → use within 4 months.

Safety Tests of slurry explosives.

① Burning Test
② Friction & Impact test (Torpedo test)
③ Impact sensitivity by hammer fall test.
④ Rifle bullet test.
⑤ Sensitivity of flame head (fuse) test.

21:13 | 57:54 0.03 KB/s 4G 24

Emulsion Explosives

→ Emulsion होते 2 liquids का mixture है जो आपस में dissolve नहीं होते हैं।

→ इसमें oxidizer & fuel दोनों ही liquid form में होते हैं।

→ Emulsion slurry में AN solution को high temperature पर diesel & emulsifier के साथ mix करके fast moving blender से पास करते हैं।

→ Blender ingredients को pumpable emulsion slurries में mix करता है जिसमें grease जैसा consistency होता है।

→ इसमें AN के microscopic droplets, fuel oil के film से surrounded होता है।

→ इसमें microspheres होते हैं जो कि एक artificially created air bubble होता है। यह emulsion को detonable बनाता है।

→ इसमें किसी भी प्रकार के sensitizer नहीं होते हैं, air bubbles sensitizer का काम कर देते हैं।

→ Emulsion explosive initiation के लिए Voids पर depend करता है। Voids में change होने पर density change होती है जिससे इसके initiation पर effect पड़ता है।

→ विस्फोट से रोकने के लिए & water resistant बनाने के लिए इसमें thickner mix किया जाता है।

→ Emulsion का gelling or cross-linking नहीं कर सकते हैं।

→ VOD particle size पर depend करता है।

→ ANFO → 2 mm size of particle → Solid form → VOD - 3.2 Km/s

→ Slurry → 0.2 mm particle size → Solid / liquid form → VOD → 3.3 Km/s

→ Emulsion → 0.001 mm particle size → Liquid form → VOD - 5 - 6 Km/s

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→ Emulsion explosives are highly water resistant

→ Slurry explosives के comparison में जादा fluidity होता है जिससे cracks & fissures में problem create होता है।

→ Emulsion slurries का ingredient cost कम होता है High density, High VOD, High energy conversion high pressure in borehole as compared to water gel slurries.

21:13 58:27 0.00 KB/s 4G 24

Create होता है,

→ Emulsion slurries का ingredient cost कम होता है High density, High VOD, High energy Conversion high pressure in borehole as compared to water gel slurries.

→ 25mm से भी कम dia के holes में यह अच्छी sensitivity show करता है।

Heavy ANFO

→ Emulsion slurries mixed with ANFO

→ water resistant & high density mixture form होता है।

→ Known as Heavy ANFO or HANFO.

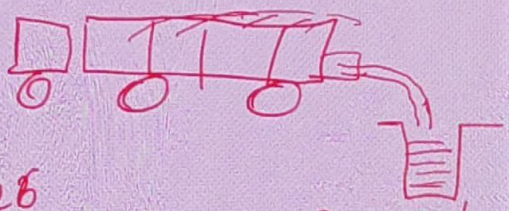
→ Emulsion to ANFO ratio → 20:80 or 50:50 it depends on watery conditions & stronger blast energy

→ High density, High energy & water resistant, better than ANFO & AN

→ Bulk density of mixture → 1.2 to 1.25 gm/cm³

→ Bulk strength → 45% more than ANFO.

SMS →



1.1 – 1.26

200 - 300 Kg/min

SME → 200 – 300 Kg/min.

→ ANFO
→ Slurry → SMS.
→ Emulsion → SME
→ Emulsified ANFO

Permitted explosive

→ fire करने पर explosives heat & flame produce करते हैं
→ Gas & Coal dust explosion U/g coal mines में avoid करने के लिए, ऐसे explosives use करते हैं जो heat & flame कम produce करें कि उसमें gas & Coal dust को ignite करने की capability नहीं होती।
→ इसलिए Coal mines में DGMS approved explosives use करते हैं।

→ Safety of permitted explosives depends on.
① Low temperature
② less flame duration, only 1/1000th seconds.
③ Cooling agent → NaCl, Potassium chloride, Sodiumfluori
④ NGC in some explosives), AN, NaCl.
⑤ In non-slurry explosive → absorbing material.

→ Types of Permitted explosives.
P1 → Unsheathed
P2 → sheathed
P3 → Equivalent sheathed
P4 → special purpose explosives → delay firing
→ firing in ripping
P5 → off the solid explosive (solid blasting) → slurry explosive, Pentady

→ P4 not manufactured in India & not used also
→ sheathed explosive → coated with sheath of $NaHCO_3$
→ $NaHCO_3$ decompose होने पर CO_2 & H_2O की blanket form करके उसे safe बनाता है।
→ Equivalent sheathed
↓
Inert material like Ammonium chloride & Soda Nitra

21:15 1:00:41 0.00 KB/s 4G 24

CO_2 & H_2O की blanket form करके उसे safe बनाती है।

→ Equivalent sheathed
↓
Inert material like Ammonium chloride & Soda Nitrate

Explosives in O/c mines

→ for Column charge, bottom charge, base charge, primer & booster.
→ Column charge explosive is non-cap sensitive.
→ 80% column explosive in blast-hole.
→ bottom में base charge (also called bottom charge primer or booster)
→ Base charge → Powerful than Column charge.
→ Cap-sensitive.

Guidelines Regarding Use of explosive

→ U/g coal mines में DGMS approved permitted explosive use होना चाहिए।
→ यह explosives cap-sensitive होने चाहिए
→ U/g metal mines & quarries में non-permitted explosives use कर सकते हैं।
→ In watery places → Gelatinous or semi-gelatinous explosives use करें।
→ NG-based explosives use नहीं करना है।

→ Slurry explosives water-resistant होते हैं। and watery holes में use कर सकते हैं।
→ Hard rocks को blast करने के लिए 2500 m/s से ज्यादा VOD के explosives का use करें।

21:16 1:01:40 0.00 KB/s 4G 24

Provisions Regarding Permitted explosive.

→ Those are explosives manufactured according to the specifications laid down by CIM.

→ CIMFR के द्वारा tests conduct करने बाद, satisf होने पर permitted explosives में cooling compounds add किए।

→ Belowground mines में अगर 2 or more shots एक साथ fire करना है तो permitted explosives ही use होने चाहिए।

→ Permitted explosive is not compulsory in.
  → A stone drift, if it does not contain dry coal dus
  → A shaft being sunk.

→ Stone drift from one coal seam to another only permitted explosive use करें।

→ In sinking shaft within 10 m of coal seam only Permitted explosive use करें।

⇒ P1 → Used in dcg. I seam, in m/c cut face
⇒ P2 → Its place taken by P3.
⇒ P3 → Dcg. 2 & 3 seams, in m/c cut face
⇒ P5 → Ultra safe explosive
  → Used with ms delay detonators in Solid Blastin
⇒ P1 explosives are strongest & P5 the weakest.
⇒ P3 का strength P5 से 20% अधिक होता है।

Conditions for Using P1 & P3

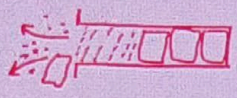
→ Blown out shot & Cut off की problem होती है।
→ इसलिए limited charge रखें, cut off & chance को minimise कर सकते हैं।
→ Maximum charge per hole
  - 1000g in case of P1
  - 790g in case of P3

21:17 | 1:02:36 KB/s 23

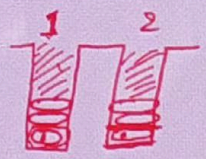
→ Maximum charge per hole
- 1000g in case of P1
- 790g in case of P3

→ इक साथ fire करें to eliminate cut off

→ Blown out shot → जब explosive & stemming material hole को blast किए बिना बाहर आ जाए



→ Cut off → जब बाकी का explosive prime charge separate हो जाए



P5 Explosives Problems & Charging

→ Problems → ① Blown out shot
② Cut off
③ Deflagration (rapid burning)

→ Deflagration तब होता है जब पिछले delay के shot के कारण explosive के cartridge पर Pressure पड़ता है और वह de-sensitise हो जाता है।

→ Maximum charge Per hole
→ In deg. 1 → 1000g
→ In deg. 2 → 565g.

Solid Blasting

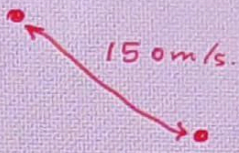
→ Multishot firing में सभी shots series में connected होने चाहिए & इक साथ fire करना है।

→ Delay detonators use करने के लिए CIM से permission लेना पड़ेगा।

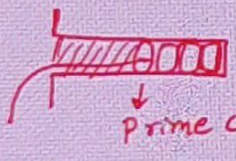
Condition for solid blasting in coal using delay detonators

Condition for solid blasting in coal using delay detonators

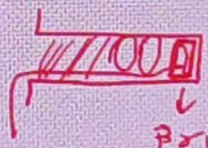
1. Only P5 explosives shall be used
2. With non-incendive ms delay detonators (also called Carrick or Coal delay detonators)
3. Maximum delay b/w 1st & last shot.
   - In deg 1 → 150 ms
   - In deg. 2 → 100 ms.



4. Delay b/w two consecutive shots.
   - They shall have different delay no.
   - Not more than 60 ms.
5. Distance b/w two adjacent shots of different delay no. → not less than 60 cm.
6. Blasting shall be done with inverse initiation



Direct Initiation



Inverse Initiation

7. Air within 4.5 m of the face → not less than 284 m³/min
8. Check CH_4 with methanometer within 20 m of the face.
9. No blasting shall be done if CH_4 % exceeds
   - 0.1 % in deg 1
   - 0.5 % in deg. 2
   - 1.25 % in deg. 3
10. Hole Pattern shall be fixed by Manager.

→ Solid blasting में wedge cut or fan cut pattern use होता है।

→ In depillaring panel → for splitting blasting is treated as solid blasting.
→ उसके बाद m/c cut face की तरह treat करते हैं।

Delay Detonators

→ Carrick or Delay Detonators, 0 to 6 delay no. में manufacture होते हैं, 25 ms के steps में। No. 6 का delay period 150 ms होता है।

→ Orica 25 ms के steps में 4_0 3_0 3_0 0^4
0 to 10 delay no. के detonators 4_0 3_0 2_0 1_0 0_0 0^1 0^2 0^3 0^4
manufacture करता है। 3_0 2_0 1_0 0_0 0^1 0^2 0^3

→ GOCL detonators → 25 ms के steps में upto no. 6.
→ 50 ms for no. 7 & 8
→ 75 ms for no. 9 & 10

→ Long delay detonators → 300 ms के steps में होते हैं।
→ Used only in stone drifts & sinking

Exploders

→ Coal mines में approved exploders use होने चाहिए
- Firing current is limited to 4 mA.
- Residual (बचा हुआ) current firing के बाद automatically discharge हो जाता है।

→ Battery condenser discharge type exploder use होते हैं।

→ Key को घुमाने पर condenser charge हो जाता है। जो कि bulb के द्वारा indicate होता है।

→ Button press करने पर Circuit में current flow होता है।

→ Exploder का design इस प्रकार का होता है कि अगर blasting circuit का resistance enploder की capacity से ज्यादा है या फिर condenser fully charged नहीं है तो blasting circuit में current flow नहीं होगा

→ Exploder का Circuit intrinsically safe होता है।

→ Cleaning & repairing → once in every 3 months.

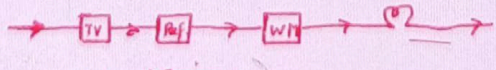
→ shall be done by competent person -

→ Repair करने वाला exploder का certificate provide कराएगा।

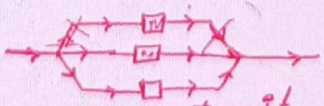
Circuit Tester

→ U/g coal mines में holes series में connected होते

Series →



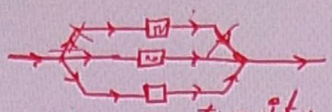
Parallel →



→ Firing के पहले resistance & continuity check की जाती है।

→ 50 mA से ज्यादा current नहीं

Parallel →



→ Firing के पहले resistance & continuity check की जाती है।

→ Circuit tester में 50 mA से ज्यादा current नही होना चाहिए।

→ other manufacturers approved current in circuit tester 4mA & 10mA.

Break Detector

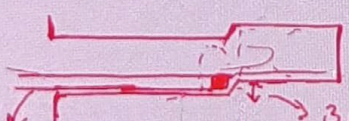
→ अगर holes में break पाया जाता है तो shot hole को fire नही करेंगे।

→ Break detector copper का बना होता है, जो की 3mm or इससे ज्यादा का break check कर सकता है।

→ Holes के end के cracks को detect नही कर पाता है।

→ Safety के लिए charging के पहले clay cartridge insert किया जाता है।

→ Scraper & break detector combined रखते है



Break detector

17:36 | 10:17 0.16 KB/s VoLTE 4G 100

Stemming material

→ Clay & sand 1 : 3 के ratio में best stemming material होता है।
→ Deg. 2 & 3 seams में water ampules use करना useful होता है।
→ water ampules blast के बाद के atmosphere में dust & fumes reduce करता है। & inflammable gas के ignition को भी minimise करता है।
→ Clay cartridge → Explosive → water ampule → Clay cartridge
→ In 1.5m hole 1 water ampule is sufficient → Length - 38cm.

Maximum no. of shots to be fired by a shotfirer.
→ Manager time to time maximum no. of shots fix करता है। It is based on—
① shots को prepare करके fire करने में time कितना लग रहा है।
② जिन जगहों पर shots fire हो रहे हैं वहाँ आने जाने में shot firer को कितना time लग रहा है।
③ shotfirer को जो assistance provide किया गया है।

Degree of gassiness	Multishot Exploder	Single shot exploder
→ deg. 2/3 or fiery	80	40
→ deg. 1 seam	100	50
→ In OC	120	60

→ higher no. of shots fire करने के लिए CIM से permission लेना पड़ेगा।

Taking shelter

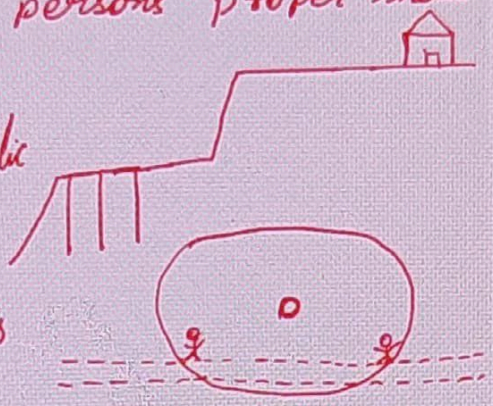
→ shots की charging, stemming or firing के पहले

Shot firer:
- shotfirer and उसके assistants के अलावा सभी ने Proper shelter लिया है।
- Prevent persons to come near shots.
- shots fire करने के पहले shotfirer अपने assistants के साथ proper shelter लेगा।

Shot firer
- shotfirer and उसके assistants सभी ने Proper shelter लिया है।
- Prevent persons to come near shots.
- shots fire करने के पहले shotfirer अपने assistants के साथ proper shelter लेगा।

→ In OC mines
- Give sufficient warning → effective means approved by manager

- Warning over entire area within 500 m of firing place (danger Zone)
- Danger Zone में सभी persons proper shelter लेंगे।
- अगर danger zone में कोई public road है तो उसके दोनो extreme positions पर red flag के साथ 2 persons को post करेंगे

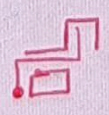


→ अगर danger zone के अंदर कोई building है तो total charge per delay and round CIM के द्वारा fix किया जाएगा on the basis of scientific study.

→ Blasting shelter must be used by shotfirer while firing shots in O/c mines.

→ जब 2 U/g workings approach within 9m of each other तो shots को तब तक fire नहीं किया जाएगा जब तक दूसरे working से workers को withdraw ना कर लिया जाए। fence लगा देना

→ In U/g mines take 2 right angles as shelter



Detonators & Accessories.

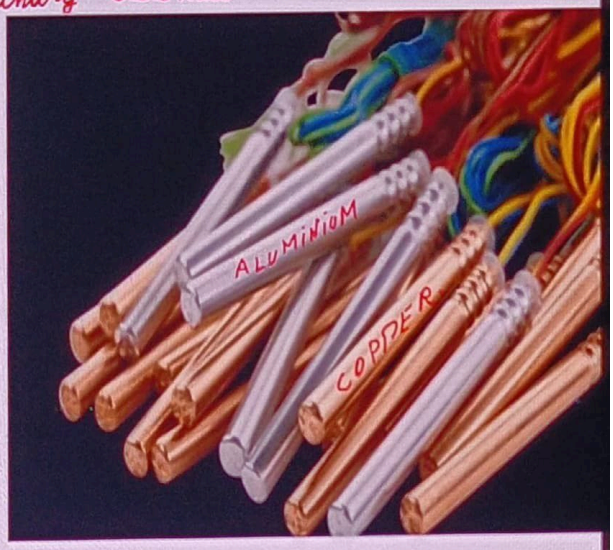
→ High explosives को initiate करने के लिए detonator or detonating fuse का use करते हैं।

→ Detonator small tube होता है, copper or aluminium का filled special explosive.

→ Special explosive को initiate करने के लिए flame or electric current का use करते हैं।

Types of Detonators

① Plain detonator → fired by safety fuse, fuse से निकलने वाले spark के कारण detonator explode explode होता है, इसे detonators को ordinary detonator कहते हैं।



② Ordinary electric detonators → fired by passage of electric current.
- ⓐ Low tension detonators
- ⓑ High tension detonators.

→ They are instantaneous type.

③ Delay detonators → यह low tension electric detonators होते हैं, इसमें phase firing करते हैं। ताकि successive round of shots को charge and fire करने का time बचे।

- ⓐ Half second or Long delay detonators
- ⓑ Milli second delay detonators (short delay detonators)

→ Plain detonators → i.e. non-electric detonators.
→ Aluminium tube → dia → 6mm
length → 37mm.
→ ASA & PETN

○ ASA → Lead Azide, Lead styphnate & Aluminium Powder
○ ASA → Prime charge & PETN → base charge.

17:41 | 15:05 0.00 KB/s 99

Aluminium

length → 37mm.

→ ASA & PETN

- ASA → Lead Azide, Lead styphnate & Aluminium Powder
- ASA → Prime charge & PETN → base charge.
- PETN is a more powerful explosive.

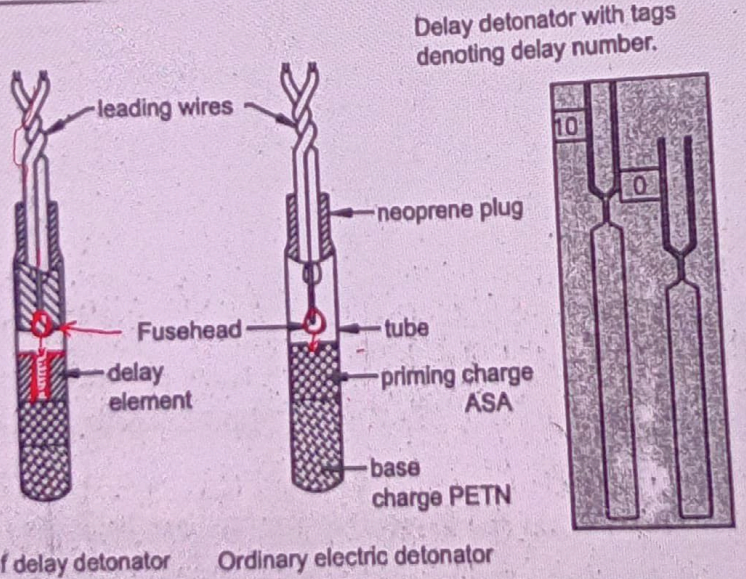
PETN → Penta Erithritol Tetra Nitrate.

→ Ordinary electric detonators → i.e. non-delay detonator
→ ASA & PETN
→ fired by passing electric current by fusehead.

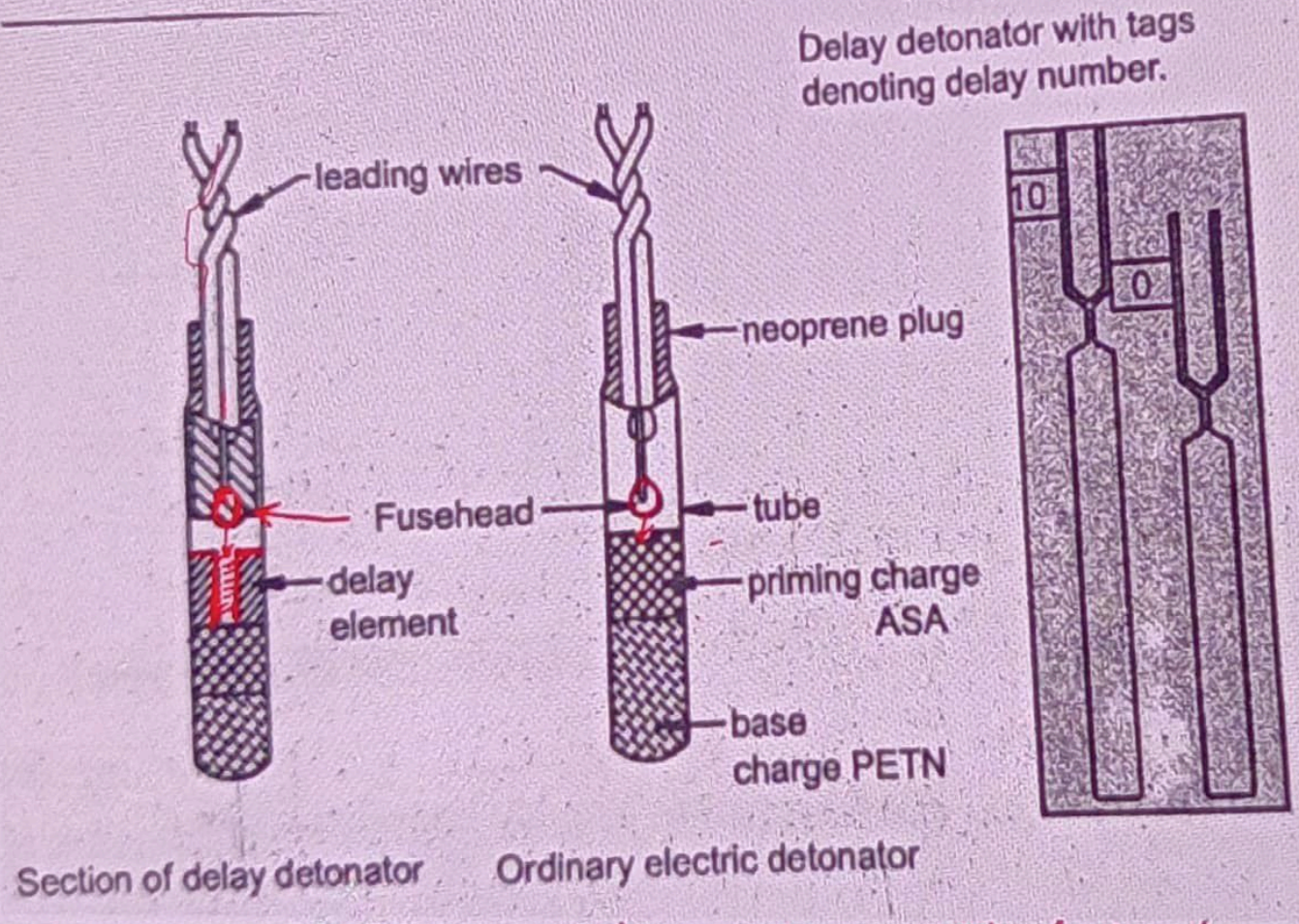
→ Low tension detonators जिसका 45m long shotfiring cable है, 7 ohms का resistance होता है
- fusehead को ignite करने के लिए 0.5A का current provide करना होता है।
- Single detonator को blast करने के लिए min.m 3.5V Voltage चाहिए।

Delay Detonators.

→ इनमें delay element होता है।
→ delay element is between fuse head & prime charge
→ Delay element → Copper or brass sleeve.
→ filled with a composition जो एक specific rate से burn करेगा।
→ Delay पाने के लिए sleeve की length को vary किया जाता है।
→ Delay & non-delay detonators can be distinguished by the colour of lead wires.



→ Delay period marked on tags attached to wires



→ Delay period marked on tags attached to wires.

→ U/g Coal mines में aluminium detonators का use नहीं कर सकते हैं पे copper detonators ही use करेंगे।

→ Aluminium detonators → Stong & highly incendive
→ Produces primary & secondary flames
→ flame duration → 14 - 18 ms.

→ Rules के according flame duration 1ms से ज्यादा नहीं होना चाहिए।

17:45 19:09 0.00 KB/s 4G 99

Advantages of Delay Detonators

1. free face की availibility के कारण explosives का consumption कम होता है।
2. Increased fragmentation
3. सभी round of shots को एक साथ fire करने से time भी save होता है।
4. Ms delay detonators के use से कम vibration produce होता है।

Accessories

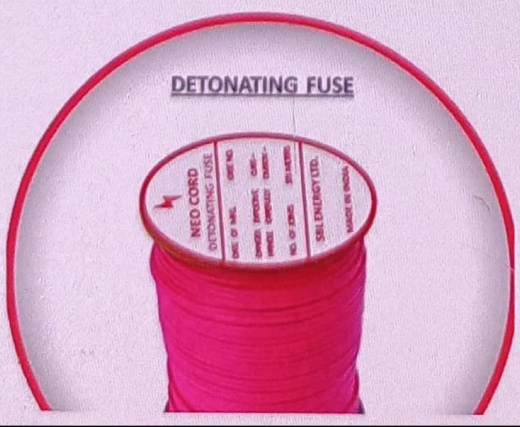
1. Safety fuse
   - यह एक Cord होता है जिसके core में fine grained gunpowder होता है।
   - Gunpowder के चारों तरफ tape की layers & waterproof coating होती है।
   - Burning speed – 100 – 120 sec/m or 0.5m/sec
   - ICI manufactures – Various brands.
     - for dry Cond^n → Double bull
     - for damp Cond^n → Blue sump
     - for wet Cond^n → OCPS & Blue plastic

→ Safety fuse के एक end को ignite करने पर flame एक Uniform rate से जाता है और gunpowder or ordinary detonator को ignite or detonate करता है।

2. Detonating fuse

→ for shallow depths upto 3m and small no. of holes में detonator को cartridge में डालकर detonate करने के लिए safety fuse & elec. detonator के case में explode का use करते हैं।

→ Large no of holes के लिए & U/g coal mines में electric detonators use होते हैं।



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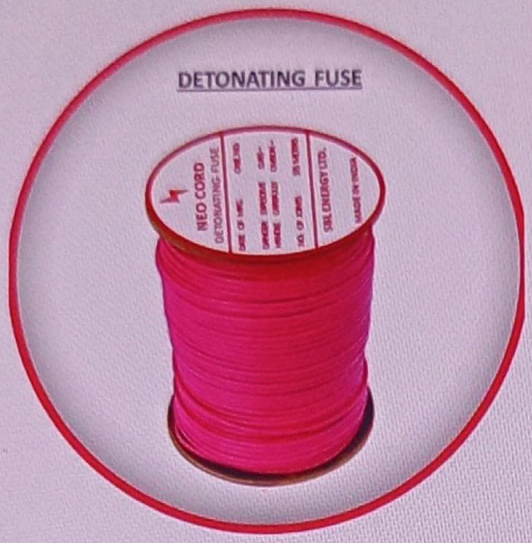
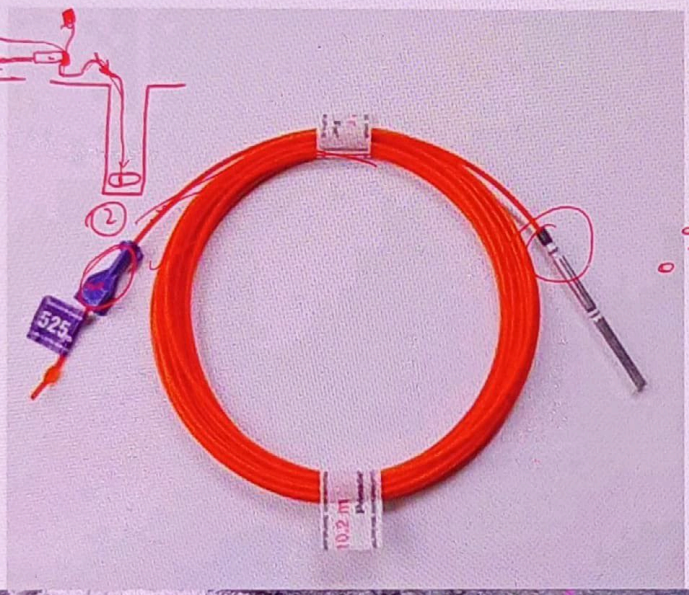
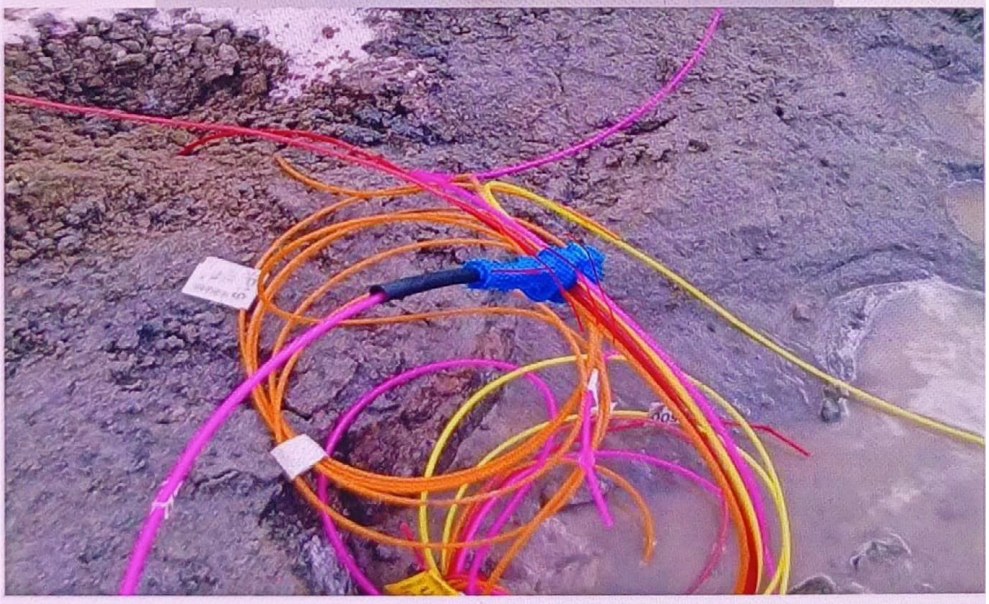


→ Deep hole blasting में इसका use होता है।
→ external dia → 5mm, weight - 20g per m length
→ VOD - 6500 m/sec
→ Large no. of shots को df से connect करके single detonator से blast कर सकते हैं।

③ NONEL
→ Primer explosives को nonel detonators के साथ blast holes में charge किया जाता है।
→ Initiate करने पर shock waves plastic tube में travel करता है।
→ Plastic tube के अंदर वाले portion में reactive substance की coating होती है, जो की 2000 m/s के rate से shock waves को maintain करता है।
→ Shock waves detonator के primary explosive or delay elements को initiate करता है।
→ Nonel means → non-electric detonator.





→ Flexible tube → External dia – 3 mm
internal dia – 1.5 mm.

→ Tubes pre cut lengths में available होते हैं।

→ इसमें दोनों ends में detonator होते हैं। एक end में sealed रहता है, other end end वाला down hole जाता है।

→ Initiated by detonator or detonating cord.

→ Advantages → ① It will not ignite due to

→ Initiated by detonator or detonating Cord.

→ Advantages → ① It will not ignite due to

ⓐ static electricity

ⓑ radio transmission.

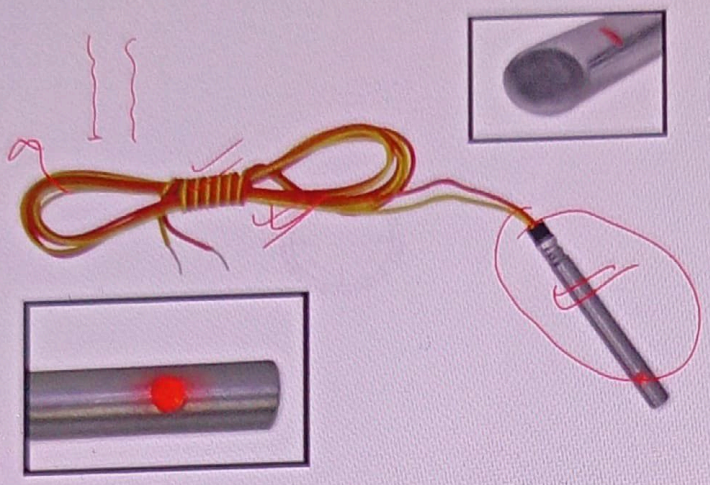
ⓒ Stray current

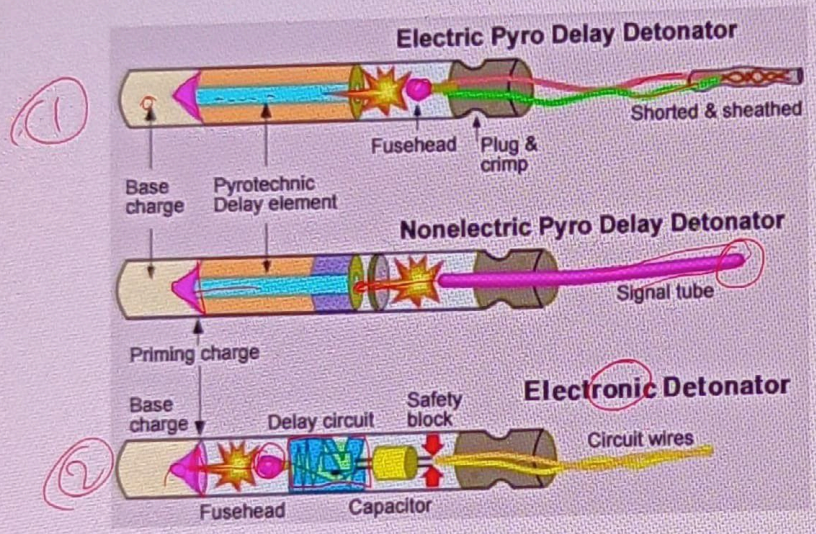
ⓓ flame.

ⓔ friction

ⓕ Impact.

② Current leakage के case में misfire नहीं होने देता है।





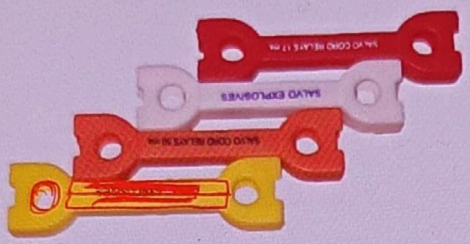
Raydet

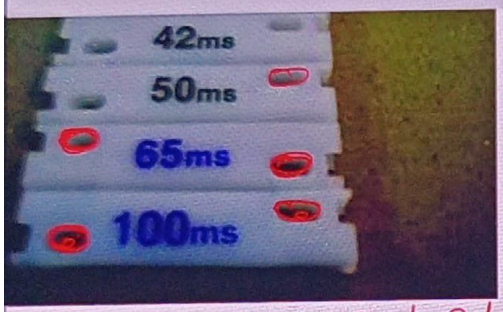
→ A non-electric initiating device.
→ A plastic tube with small quantity of explosives inside it.
→ इसके एक end में instantaneous or delay detonator crimped होता है।
→ Can be initiated by detonating cord or detonator
→ Length of tube 3m to 45m.
→ Delay no.s → 0-15
  → No. 0 delay – Instantaneous
  → No. 1 delay → 50ms
  → NO 15 delay → 625ms.

Detonating Relays

→ Df is used for its initiation
→ इस method में electrical connection को avoid करने के लिए delay detonators में use होता है।
→ Detonating relay में 2-open-ended delay detonators होते हैं जो कि flexible neoprene tubing से coupled होते हैं, Aluminium sleeve के अंदर ——— रखे जाते हैं।

→ Detonating relay में 2-open-ended delay detonators होते हैं जो कि flexible neoprene tubing से coupled होते हैं, Aluminium sleeve के अंदर
→ इस Df के साथ Crimp कर सकते हैं।
→ इसके दोनों ends में delay element होता है
→ Delay interval for each detonating relay 15-45 ms.





VOD → 2000 m/s.

Cord Relays

→ Delay detonating relays को Cord Relays के trade name से manufacture किया जाता है।
→ Cord relay dia → 11.5 mm.
length → 152 mm.
→ Available with 2 delay periods → 15ms & 25ms.

Classification of Explosives

Class-1 → Gun Powder
Class-2 → Nitrate mixture
Class-3 → Nitro compounds ✓
Class-4 → Chlorate mixtures
Class-5 → Fulminate.
Class-6 → Aluminium safety fuse, detonating fuse, detonator, detonator Relay
Class-7 → Fireworks
Class-8 → Liquid Oxygen explosive.

Circuit Tester

Shot firing Cables

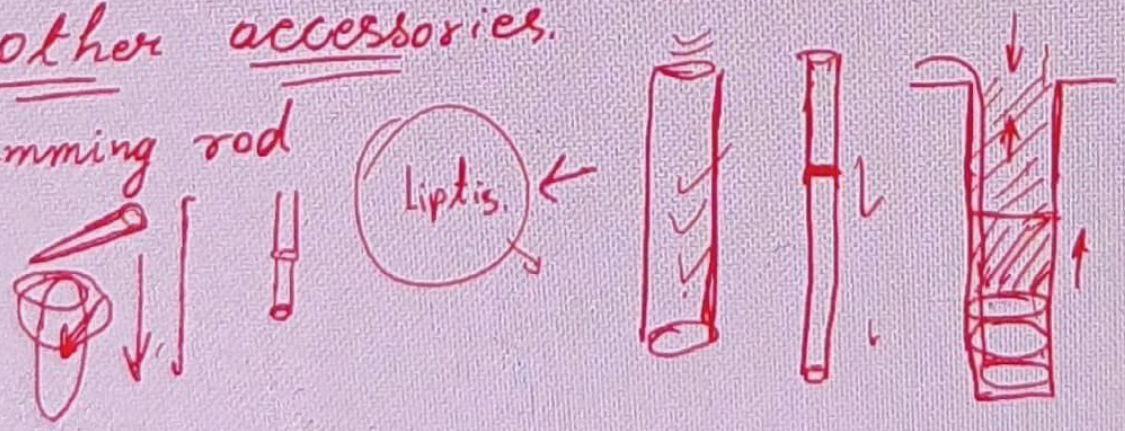
→ Electric shot firing के द्वारा detonators की leads को long shot firing cables से connect कर दिया जाता है।

→ Length → not less than 50m.

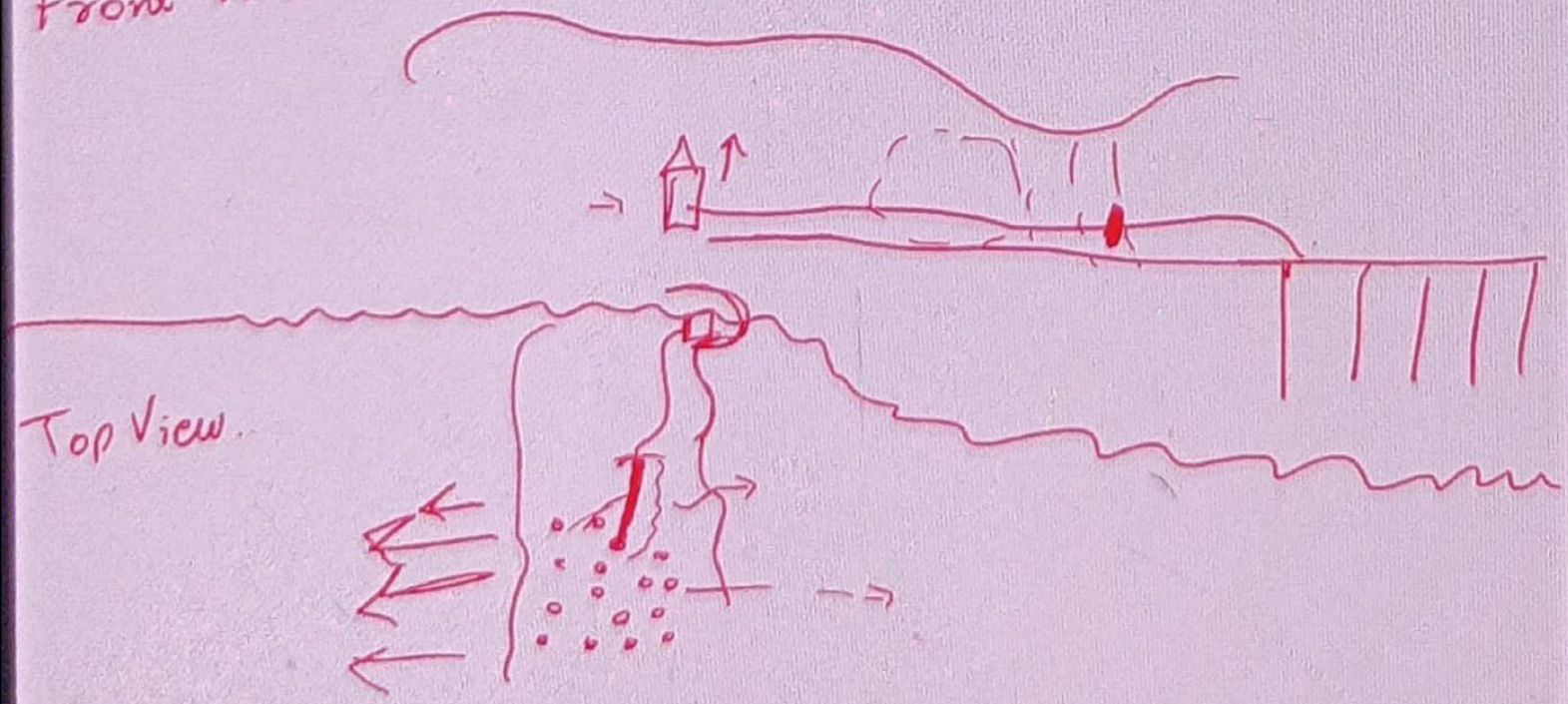
→ Twin Core cables are used & withstand 250V.

other accessories.

→ Wooden stemming rod
→ Scooper
→ J-hook
→ Pricker



Front View

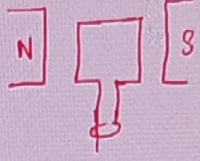


Top View.

Exploder

→ It is safer than using safety fuse.
→ Electric power lines are not permitted.
→ यह एक Portable apparatus है जो कि electric detonators को firing के लिए current provide करता है।

① Magneto (Dynamo) Exploder



→ Armature 2 different poles के magnet के बीच rotate करता है।
→ Voltage की value armature की speed of rotation पर depend करता है।
→ Low tension exploder gives about 15V.
→ Single shot exploder 1 or 2 shots fire at a time
→ 6 shots fired by 6-shot exploder.
→ Exploder for U/g coal mines are intrinsically safe.

② Battery Condensor.

→ It has 4 or more cells making a battery.
→ 1.5V per cell.
→ It has a detachable key.
→ Shot firing cables के दोनों terminals को exploder से connect करके key को एक step clockwise rotate करने पर condenser charge हो जाता है। और neon lamp glow करने लगता है।
→ Key को फिर से anticlockwise rotate कर off position पर लाते हैं & detonators explode हो जाते हैं।

→ Rhino-25 → firing current → 1.5A
Input DC Volts → 6V
Output DC Volts → 600V.
firing current duration → 3-4 ms.

③ Condensor Dynamo Exploder

→ Used where inflammable gas is not present.
→ Output voltage → 750 DC Voltage.
→ Circuit resistance → 160 Ω
→ Duration of current → 5-6 mS.

Transport & Storage of Explosives

→ Magazine → A building where explosives & detonators are stored
→ For contruction & site of construction approval has to be taken by Inspector of explosives.
→ The min.m distance of residential quarters & roads from the magzine depends on its capacity

17:56 | 29:40 0.00 KB/s Vo LTE 4G 97

be taken by Inspector of ...

→ The min^m distance of residential quarters & roads from the magzine depends on its capacity.
→ Larger capacity ⇒ longer safe provide किया जाता है।
→

→ Small magazines → Inside the mine boundary.
→ License in Form J.
→ Capacity → 45 Kg gunpowder
→ 5 Kg NG
→ 200 detonators
→ 50 Kg slurry explosive.
→ Any quantity of safety fus

→ Large magazines → Inside the mine boundary.
→ License in Form L
→ capacity → 25000 Kg explosive.
→ 2,00,000 detonators.

→ Permission for construction of magzine.
→ Application in form C & D दिया जाता है to Regional controller of explosive (RCE)
↓
with 6 copies of site plan & magzine construction details.
↓
RCE documents को Chief Controller of Explosive को forward कर देगा।
↓
CCE form E issue करेगा & इक draft copy of License L and इक Copy site plan को DM के देगा to issue 'No Objection Certificate'
→ इसके बाद CCE magzine Construction के लिए allow कर देगा & License L issue करेगा।
→ Magzine के Construction के बाद RCE inspect करेगा and approve कर देगा।
→ Licence का renewal annually होता है।
→ Portable magzine → License CCE issue करेगा
→ Area → 5m × 2m.
→ Distance from all buildings - 95m
→ Roads → 48 m
→ overhead tension line → 91m.

PESO → Petroleum & Explosives safety Organisation
(Established during British India in 1890s

PESO → Petroleum & Explosives Safety Organisation

→ Established during British India in 1890s as Department of Explosives

→ Head → Chief Controller of Explosives

→ Headquarter → Nagpur (Maharashtra)

→ The officers are selected by UPSC

↓

Indian Petroleum & Explosives Safety services.

17:58 | 32:01 KB/s

Deterioration In Quality During storage

→ Storage के time, hot & humid conditions के कारण explosives का chemical composition change होता है।

→ Explosives may become insensitive.

→ Explosives अगर good condition में हैं तो उसका wrapper easily remove हो जाएगा।

→ There will be no evidence of discoloration, softening & liquidation.

→ Gelatinous explosives storage पर slightly dark हो जाता है, particularly moisture के कारण इसके ends में यह होता है।

→ Gelatinous explosives moisture absorb करने पर इसके ऊपर एक ammonium nitrate & sodium nitrate की white layer form होती है।

→ ज्यादा खराब होने पर NG or aq. sol.^{n} of Sodium & Ammonium nitrate बहने लगता है और Cartridge plastic nature का हो जाता है।

→ ऐसे explosive का use ना करके destroy कर देते हैं।

→ Powdery NG → Moisture के कारण explosives जल्दी खराब होते हैं।
→ discolouration at ends, softening
→ Liquid निकलने पर cartridges को destroy कर दिया जाता है।

→ Ammonium Nitrate → TNT के साथ mix होने cake जैसा हो जाता है and moisture absorb करके solid हो जाता है
→ अगर cartridge इतना solid हो जाता है कि उसे तोड़ा न जा सके तो destroy कर देना है।

→ Slurry Water gel emulsion explosives → इसके खराब होने के indications → इसका gel liquid & solid components में break होने लगता है।
→ कभी ऐसा भी होता है की cartridge hard हो जाता है।
→ Cartridge के बाहर salt के crystals निकलते हैं।

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→ Cartridge के बाहर salt के crystals दिखते हैं।

→ Detonator → Signs of Corrosion
→ plain detonators.

→ Detonating Cords → जब moisture explosive core को affect करने लगे
→ लंबे समय तक sunlight में रखने पर DC की plastic outer covering brittle (नाजुक) हो जाती है। explosive

Destruction of unserviceable Explosives

→ Gunpowder → इसे hot water में फेंक देना है। ऐसा करने पर इसका salt पानी में dissolve हो जाएगा।

→ AN explosives → hygroscopic होने के कारण इसे जमीन में गाड़ देना है और moisture absorb करके यह harmless बन जाता है।
→ Large Vol^m of water में भी dispose कर सकते हैं।

→ Explosives with NG → एक बार में 25 kg से ज्यादा destroy नहीं करना है।
→ 100m के radius में dry grass नहीं होनी चाहिए।
→ Cartridges को dry grass पर एक line से cartridge wrappers के ऊपर बिछा दिया जाता है। 25 mm के intervals पर
→ dry grass सभी cartridges के बिछाने के बाद 6m आगे तक बिछाया जाता है।
→ इसके Kerosene sprinkle किया जाता है।
→ Safety fuse से dry grass को जलाया

→ इसके Kerosene sprinkle किया जाता है।

→ Safety fuse से dry grass को जलाया जाता है।

→ Safety fuse → open area में जलाया जाता है।

→ Detonators → नदी के गहराई में फेंक देना है।

→ 48 hours तक mineral oil में डुबा कर रखना है and then जला देना है।

18:02 35:29 0.00 KB/s 4G 96

Drilling Patterns in stone

→ also called shoto hole patterns

1. Pyramid cut or Cone cut.
2. Wedge cut
3. Drag Cut
4. fan Cut
5. Burn cut
6. Coromant Cut
7. Ring cut.

→ एक hole 0.3 to 0.5 m^2 का area cover करता है।

→ holes 0.45m की vertical distance पर किए जाते हैं।

→ Trimmers 0.6m के intervals पर किए जाते हैं round the perimeter of drift.

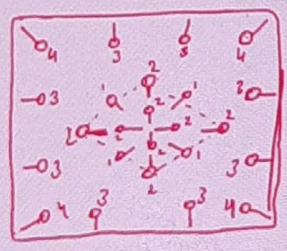
Pyramid cut or Cone cut

→ इसमें holes को square के corner से centre की तरफ drill किया जाता है।

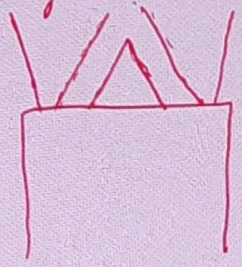
→ sides से 0.7m to 1m की दूरी पर।

→ Cone cut में holes को polygon के corners से centre की तरफ drill किया जाता है।

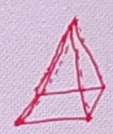
→ Depth is 50 to 60% of the width of drift

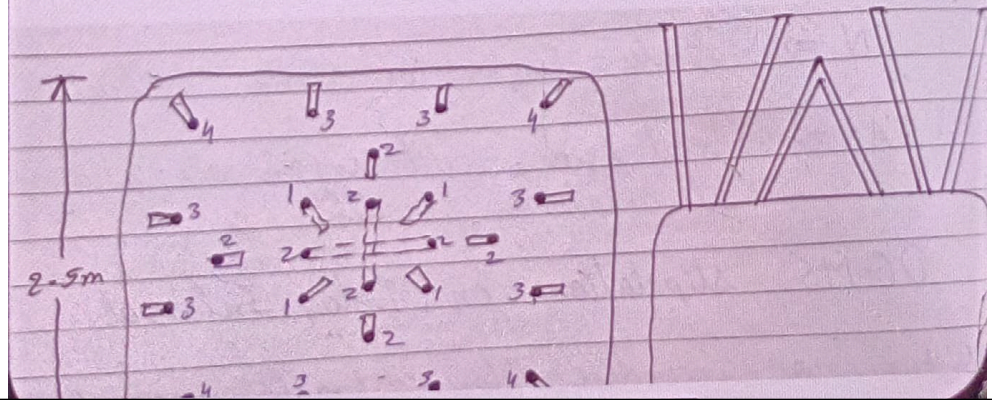


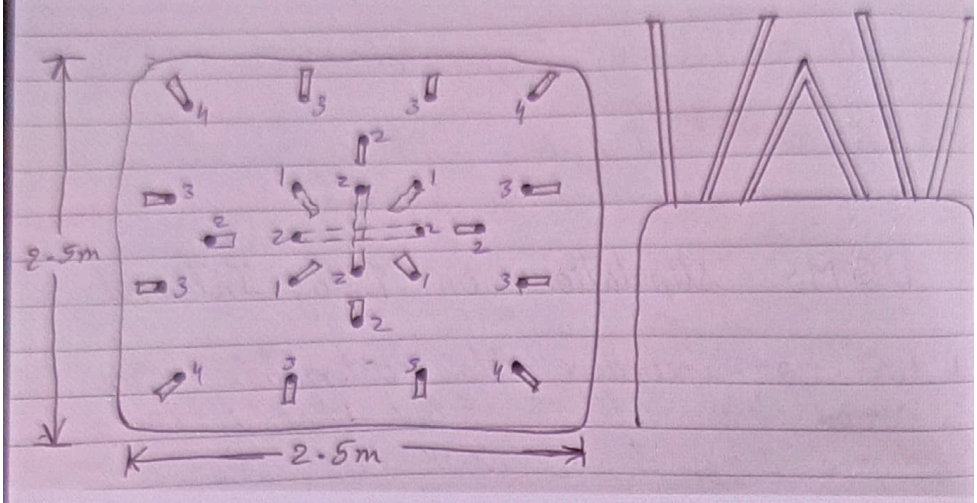
front View



Top View

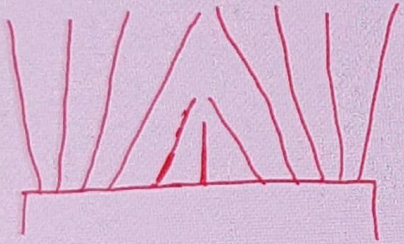




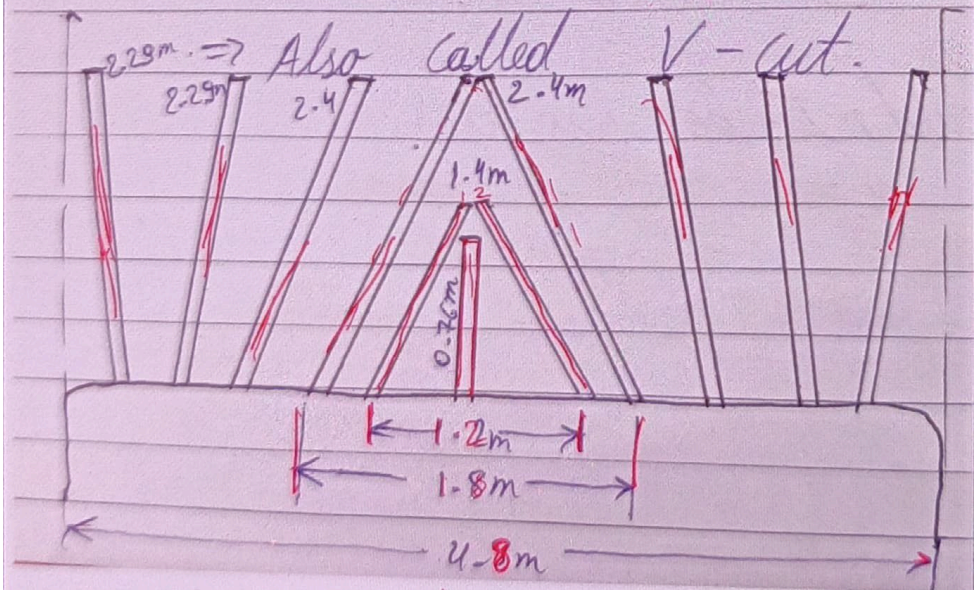


wedge cut → wedge के form में 2 से 4 pairs के holes drill करते हैं।

→ हर एक pair drift के sides से 45° के कोण के angle पर centre की तरफ drill किए जाते हैं।



→ also called V-cut



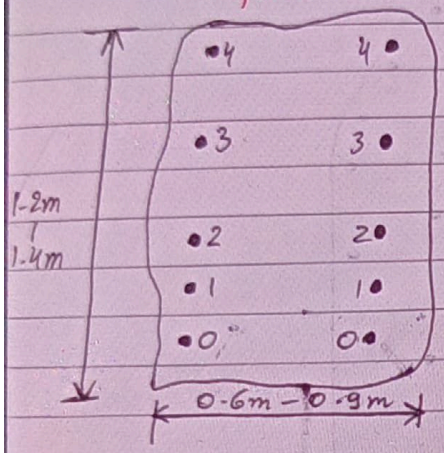
→ Pyramid cut & Wedge cut is used in uniform thick beds & hard rocks.

→ Drag cut → Drag cut small drifts में use होता है। 1.8 m से 2.4m की wide drifts में।

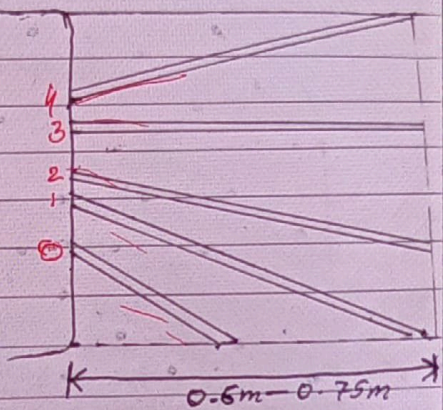
→ drill holes cleavage plane के along में है तादि strata cleavage plane

→ drill holes cleavage plane के along होते हैं ताकि strata cleavage plane के along break हो।
→ यह pattern cleavage के direction पर depend करता है।

front View

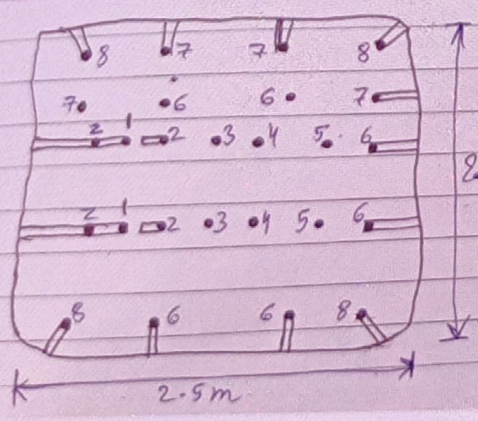


Side View.

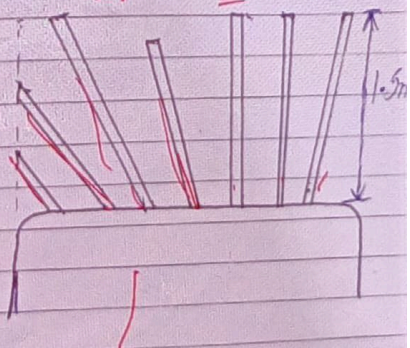


→ fan cut → fan cut laminated strata, soft strata के लिए favourable है।
→ Used in BOS in coal mines.
→ It is one half of wedge cut.
→ Depth of Pull is 1.5m.
→ hard ground के लिए यह cut recommend नहीं किया जाता है।

front View



Top View



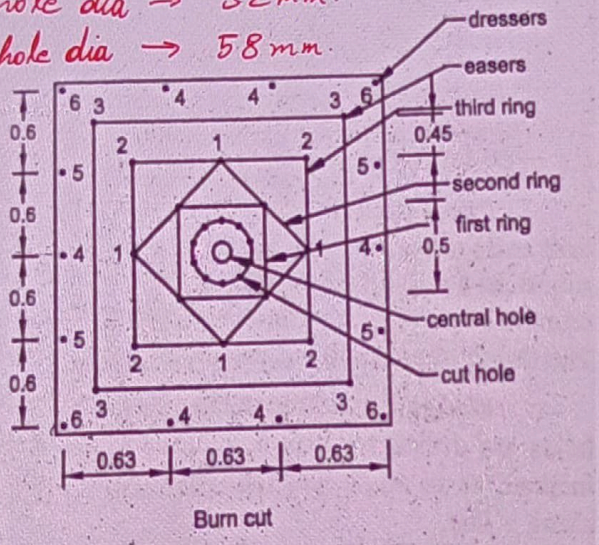
Burn Cut

→ 11 holes at right angles to face drill किए जाते हैं।

Burn Cut

→ 11 holes at right angles to face drill किए जाते हैं।
→ कुछ holes larger dia के drill किए जाते हैं and उन्हें uncharged छोड़ दिया जाता है। to provide relief to the heavy conc" of charged holes.
→ best for → hard, brittle and homogenous ground जहाँ कि rock बराबर break होता है।

→ Charged hole dia → 32mm.
→ Uncharged hole dia → 58mm.



Advantages of Burn Cut

→ Reduced time and easier supervision because of straight holes
→ Pull का depth, drift के size पर depend करता है।
→ holes cluster के form में होते हैं जिसके कारण blasted material ज्यादा दूर तक नहीं जाता है।

Coromant Cut

→ यह parallel holes cut होते हैं ताकि हर round पर ज्यादा advance हो
→ small area के tunnels और drifts में use होता है।
→ Coromant cut में एक खाली slot होता है जिसके चारों तरफ 6 holes होते हैं।
→ Slot को uncharged रखते हैं।
→ Drill rod dia → 20mm

चारों तरफ 6 holes होते हैं।
→ slot को uncharged रखते हैं।
→ Drill rod dia → 20mm
→ Drill bit dia → 57mm
→ slot → 2 contiguous holes are drilled.

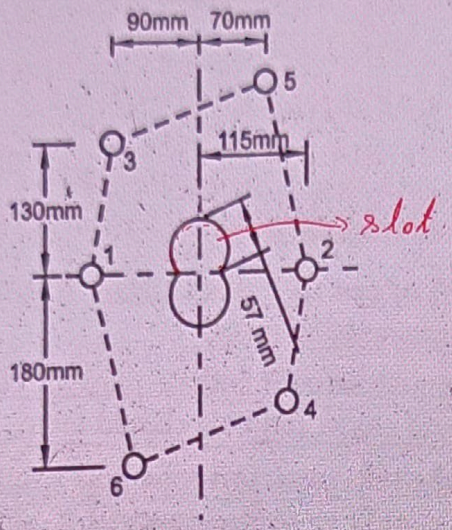


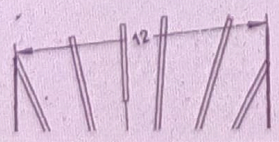
Fig. 8.9 Coromant cut pattern

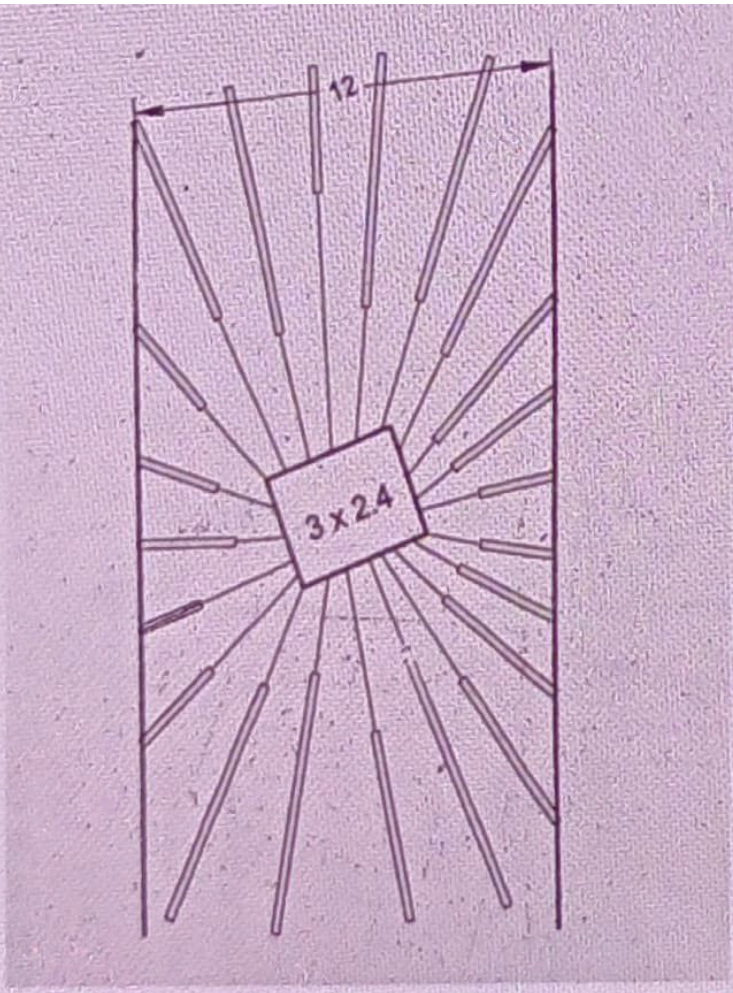
→ Accurate holes drill करना एक important factor है।
→ holes में guide tube use करते हैं।
→ 6-holes template drill m/c use होता है।
→ slot में expander डालते हैं।
→ charge → 0.3 - 0.4 kg/m length of hole
→ fired by delay in sequence

Ring Drilling

→ It is of 2 types
  (a) Vertically ring drilling
  (b) Horizontal ring drilling

→ Vertically ring drilling → drilled in vertical planes
  → like a fan to break vertical face.
  → applicable in sublevel stoping.





→ Horizontal ring drilling → drilled in horizontal plane
→ like a fan to break horizontal face
→ applicable in shrinkage stopping.

→ blasted with short delay intervals of 25 ms.
→ breaking from centre to side walls.

18:08 | 41:21 0.14 KB/s 4G 94

Advantages of solid blasting

1. It eliminates the use of CCM.
2. skid mounted coal cutter का use 2.2 m height तक की seams में करते हैं but उसके लिए hard roof चाहिए & solid blasting इसमें एक advantage है।
3. Saving in capital expenditure on equipment at the face like CCM, GEB, cables etc.

Preparation of charge

→ shot holes में एक या उससे अधिक cartridges डालते हैं।
→ एक cartridge में detonator insert किया जाता है उसे primer cartridge कहते हैं।
→ अगर electric detonator is used to prepare a primer cartridge, तो cartridge के एक end में pricker से hole करके, detonator को explosive में अच्छे से insert किया जाता है। उसके leading wires को cartridge के around बांध देते हैं ताकि detonator accidentally बाहर न आ जाए।

Charging a shothole

→ stemming material के cartridge को सबसे पहले में push किया जाता है
→ उसके बाद बाकी का charge, hole में डालते हैं and last में primer cartridge push करके डालते हैं ताकि detonator का bussines end charge की body की तरफ point करे।
→ इसे direct initiation कहते हैं।
→ इस position में detonator की strongest waves सभी cartridges को explode कर देता है
→ Direct initiation से fire damp ignite नहीं होता है।

→ Reduces risk of blown out shots.
→ Inverse initiation is practised at
  - In sumping or cut in shafts & tunnels
  - when using delay detonators to fire a round of sho
→ Charging के बाद stemming material hole में push करते है
→ stemming material compact रहे पर in form of plastic sand: clay → 3:1 & dried at the surface in form of cartridges of 150mm to 200mm long & 25-30m

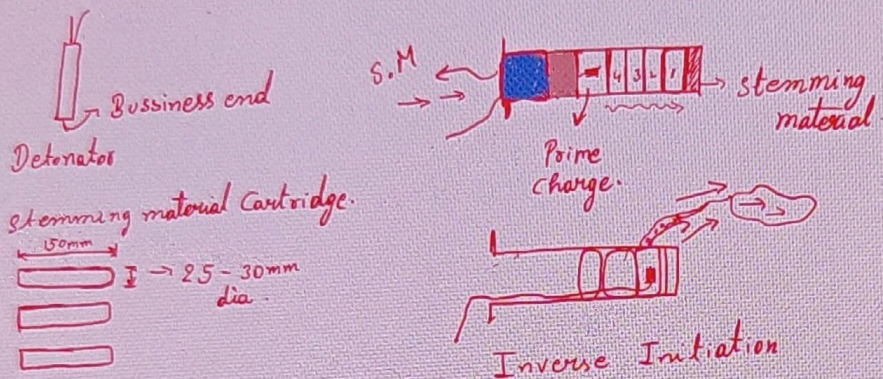
18:09 | 42:40 0.08 KB/s 4G 94

• When using delay detonators to fire a round of shot

→ Charging के बाद stemming material hole में push करते हैं

→ stemming material compact रहे इस in form of plastic sand : clay → 3 : 1 & dried at the surface in form of cartridges of 150mm to 200mm long & 25-30mm dia.

→ first 2 to 3 cartridges को lightly push करते हैं उसके बाद hard tamping करते हैं।



Complete Procedure for shot firer

1. Test holes for break. If crack found donot charge.
2. Test for gas within 8m of the hole.
3. अगर CCM less करे रहे हैं तो shot hole की depth cut से 150mm कम होना चाहिए।
4. Roof में shot hole का direction mark करे रहे।
5. Charge the shothole with explosive
6. Stem the hole, first lightly and then hard.
7. Spray stone dust within 90m of hole.
8. Warn the workers and place helpers 27m away.
9. Layout shot firing cable

→ Test again for gas within 18m.

→ Couple firing cable with detonator wires. detonators leads series में होना चाहिए।

→ Take shelter.

→ Couple shot firing cable with exploder

→ Shout a warning again.

→ After blasting, Allow the fumes & gases to clear.

→ Return to shot hole, examine the roof, sides & timber support and shout "all clear" to workers to return to their work if the place is safe.

→ If needed dressed by dressers.

18:10 | 43:59 0.00 KB/s 4G 94

Ignition Gases

① By the flame and hot gases → flame को sufficiently cool करना जाता है जो कि gas की ignition point से low होता है। और gas ignite नही होता है।

② By incomplete detonated explosive → इस case में explosive normal material की तरह जलता है।

③ By incandescent particle → Blasting करने पर अगर कोई particle coal dust or gas के contact में आता है।

④ By the compression wave of the blast. fissures और breaks में अगर gas है और वह shot hole से connected है तो blasting करने पर heavy compression के कारण gases का temperature बढ़ जाता है और ignite हो जाती है।

Blown Out shots

→ कम Charge के कारण यह होता है।
→ Overcharge करने पर blasting के बाद भी explosive जलता रहता है इससे gases & coal dust ignite होती है।

Common Causes of Accidents

① Not taking proper shelter → shelter, shots के direct line में नही होना चाहिए
→ At least take 2 right angle

② Failing to warn persons.
③ Carelessness in handling detonators.
④ Carelessness while charging a hole
⑤ Firing a shot when persons are at the face.
⑥ Returning to face too early after blasting.
⑦ Dealing with misfired shots.

Misfired shot

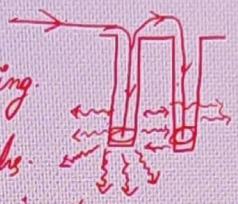
→ When detonator fails to explode or blasting के बाद main cartridge explode नही होता है।

→ Reasons of misfire
① Defective firing exploder
② Defective detonator or bad quality explosive
③ Broken detonator leads, defective or broken shotfiring cable

18:11 | 44:34 0.36 KB/s 4G 94

→ Reasons of misfire
① Defective firing exploder
② Defective detonator or bad quality explosive
③ Broken detonator leads, defective or broken shotfiring cable
④ short circuit of the cable due to poor or broken insulation
⑤ Bad connection b/w exploder & cable

⑥ Where fuse blasting is done it may be due to
① wet fuse
② Improper timing of fuse
③ The fuse being broken during stemming.



→ exploder examination → once in 3 months.

Dealing with a misfired shot in U/g

→ Entering the blasting site after blasting
① In case of firing by safety fuse → after 30 minute
② In case of firing by elec. detonator → after 5 minutes after disconnecting from exploder.

→ All entrance to be fenced
→ shot firing cable से proper connection करके उस ओर attempt करेंगे blast करने का।
→ if does not explode, तो 0.3m की distance पर उस relieving hole करेंगे।
→ Drilling shot firer के presence में होना चाहिए
→ Relieving shot के blasting के बाद misfired cartridges and detonators को search करेंगे।
→ अगर नहीं मिलता है तो material को separate tub में load करेंगे।

→ मिलने पर surface पर ले जा कर destroy कर देना है।
→ Second Option → Compressed air or water से stemming material को निकाले & hole को reprime करके blast कर देंगे।
→ Scrapping करके stemming material को नहीं निकालना है।

18:12 | 45:44 0.02 KB/s 4G 93

Liquid Oxygen Explosive (LOX)

→ O_2 gas liquifies at $-183°C$
→ Combustible material को liquid O_2 में absorb करवा दिया जाता है।
→ Reaction करवाने पर huge Vol.ⁿ of gas high temperature & pressure के साथ release होता है।
→ VOD more than 5000 m/s.
→ LOX is used for
① removal of OB
② quarries of coal
③ Metal mines

→ Can't be used in U/g Cal mines.
→ Indian Oxygen Ltd.
① Small cartridges → dia 25mm to 90mm
② Large Cartridges → dia 100mm to 210mm
→ Small group cartridges → 38mm dia × 300mm long.
→ Large group Cartridges → 190mm dia × 600mm long also called full Cartridge.
→ Depots में LOX Cartridge prepare करने के लिए absorbent Cartridge को liquid oxygen absorb कराया जाता है।
→ Absorbent cartridge → Cellulosic substance like jute stalk, or agricultural produ

→ hydrocarbons & metallic powder are added to it.
→ Coal mines में use करने के लिए Loxite - C नामक absorbent use होता है to reduce temperature.
→ Lox cartridges को coal mines में magazine में store नहीं किया जाता है।

Characteristics of LOX

① Its characteristics are not constant because it depends on the time gap b/w firing & removal of cartridge from soaking vessel.
② LOX does not require a booster
③ Large blasts are not suitable for LOX due to consumption time in charging, stemming firing is more. Oxygen gets evaporated.
④ Highest standard of safety.
⑤ It can be fired with or without detonator
It can be fired by safety fuse.
⑥ Not suitable for watery strata

18:13 46:36 0.78 KB/s 4G 93

⑥ Not suitable for watery strata.

→ LOX को half an hour में ही use कर लिया जाना चाहिए otherwise liquid oxygen evaporate हो जाएगा।

→ Life of LOX in open → 1 hour.

→ Life of LOX increases with confinement of hole.

→ when it comes in contact with water it gets evaporated quickly.

→ watery holes में polythene bags में pack करके holes में charge किया जाता है।

→ 3m से ज्यादा depth में use करने के लिए Df का इस्तेमाल किया जाता है।

Blasting Practise in O/C Mines.

→ Efficient blasting → ① desired fragmentation मिले
② Eliminate secondary blasting

→ Quantity of explosive consumption.

① Rock blasted per hole (m^3) = depth of hole × burden × Spacing

② Rock blasted by round of holes → depth × burden × spacing × no. of holes.

Q → 50 holes → Sp. gr. → 2

Spacing → 3m, burden → 2.5m.

Depth → 8 m.

what tonne of Rock will be blasted

Sol^n → Rock blasted in tonne = spacing × burden × depth × no. of holes × sp. gr.

= 3 × 2.5 × 8 × 50 × 2

= 6000 te

per metre कितने tonne material blast होगा।

Total = 6000 te

Total drilling ⇒ 8m × 50 → 400 m.

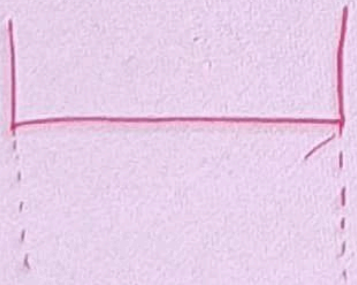
per metre ~~[illegible]~~ tonne material blast ~~[illegible]~~

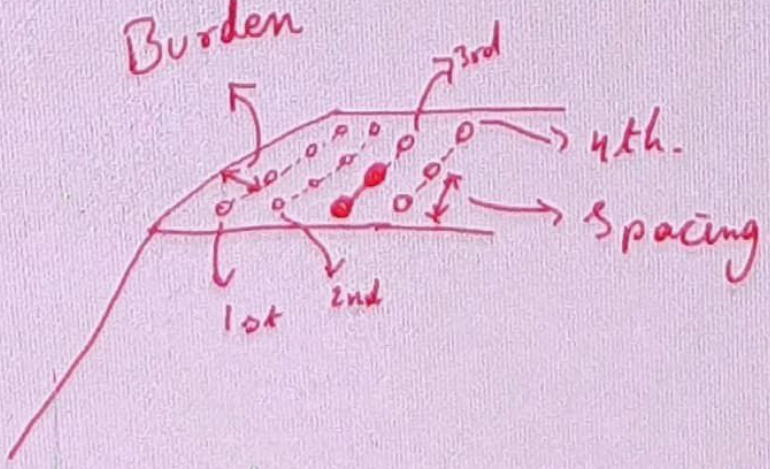
Total = 6000 te

Total drilling ⇒ 8m × 50 → 400 m.

15
6000
400
1

15 te per metre.





Burden → dist b/w Two rows or free face & hole.

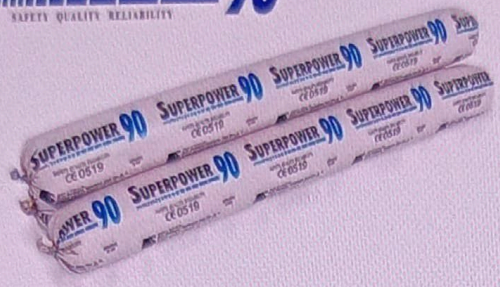
Spacing → Dist. b/w Two hole in the same ro

Depth & pattern of blast holes

→ Vertical holes are drilled
→ Depth of holes - height of bench
→ In hard rock → Subgrade drilling करते हैं जो की bench floor से 0.5 m to 1m deep होता है।
→ Subgrade drill bench के toe को loose करने के लिए किया जाता है।
→ In hard rocks spacing & burden bench height का 0.3 to 0.4 times
→ In less hard rocks (coal, sandstone) → spacing & burden is 0.5 to 0.8 times of bench height.

Preparation of Primer cartridge & charging blast hole

→ Pricker की help से cartridge के top से 10-15cm नीचे इक hole करते हैं and df को उसमें pass करके उसके around बांध देते हैं।
→ अगर LOX है तो df को cartridge में डालने के लिए hole नहीं करते हैं।
→ Primer cartridge hole के bottom में होता है
→ Primer explosive slurry or ANFO explosive का 15-20%



→ Deck loading → explosive को अलग अलग section में holes में charging करते हैं।

→ This technique is used for getting better rock fragmentation.

→ This technique is used where alternate soft & hard strata are found.

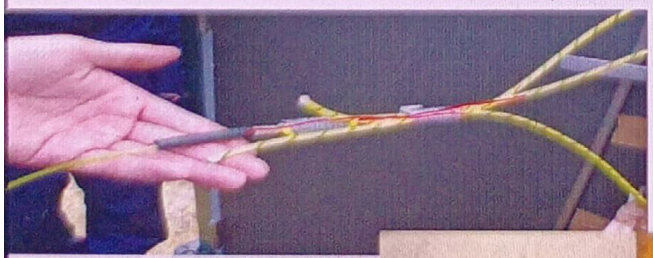
→ bottom most primer cartridge को different deck के primers के साथ threading कर देते हैं।

→ Lox cartridges को watery holes में use करने के लिए polythene bags में pack करके holes में डाला जाता है।

→ उसके ऊपर sand bags डालते हैं ताकि liquid oxygen evaporate होने पर surface पर ना आए।

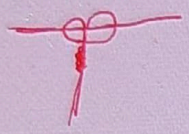
→ holes की drill chips से stemming कर देते हैं।

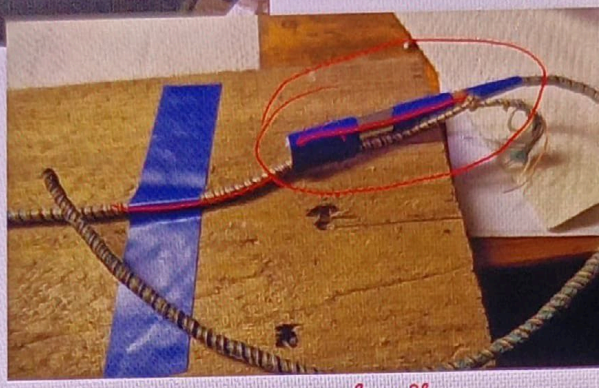
→ Df को hole के बाहर 1m length का cut कर लेते हैं।



Df Connections

Df Connections





→ Fly rock approx 300m तक जाते हैं।

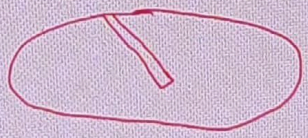
→ Blasting site के 500m के अंदर workers को withdraw कर लेना है

→ Machines को किसी safe जगह पर रखना है जो की blasting site के direct line में नहीं।

→ Blasting करने के half an hour पहले shotfirer siren बजाकर warning signal देगा and दूसरा blasting करने के 5min पहले warning signal देगा।

Secondary Blasting

① Pop shooting
② Plaster shooting



Pop Shooting

→ Jack hammer से holes drill करते हैं boulder में

→ Depth of hole → 0.3m to 0.6m

Plaster Shooting

→ Prime cartridge along with other cartridges के साथ boulder के surface पर रखा जाता है

→ उसे plastic clay से cover करते हैं। हाथ से धीरे से दबा कर

Plaster shooting

→ Prime cartridge along with other cartridges के साथ boulder के surface पर रखा जाता है

→ उसे plastic clay से cover कर देते हैं। हाथ से धीरे से दबा कर

→ Plastering करने के पहले उस जगह गीला कर लिया जाता है।

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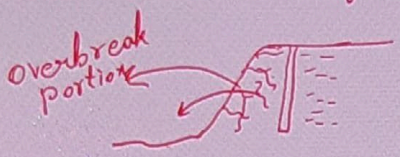
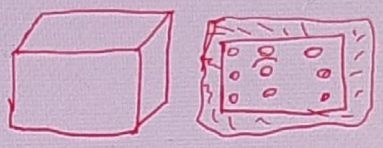
Controlled Blasting

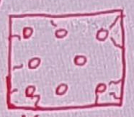
→ Extra production करके trasport करना है।
→ Overbreak portion का जहाँ पर backfilling करना होता है
→ Roof Controlling measures में use होता है।
→ where blasted below water level.
→ where maintenance of roof/face/sides is more



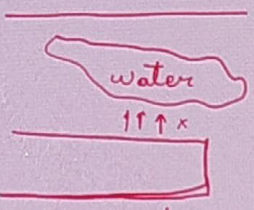


Perimeter Blasting

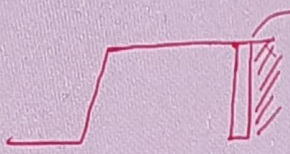
→ blasting के कारण जो damage



होता है वह excavation वाले area तक ही limited होगा।



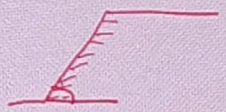
blasting below water level



Factors affecting controlled blasted.

→ Geology
→ Explosives properties.
→ Bench parameters
→ Type of excavation

[Geology]



→ blasted वाले zone के पीछे की rock की strength कम हो जाती है, This is caused due to high charge per delay.

Uses of Perimeter Blasting

→ Reduce backbreak.
→ Reduce charge quantities
→ Drill extra holes to reduce charge per hole.

Reducing break

→ Perimeter blasting, normal blasting से ज्यादा expensive,

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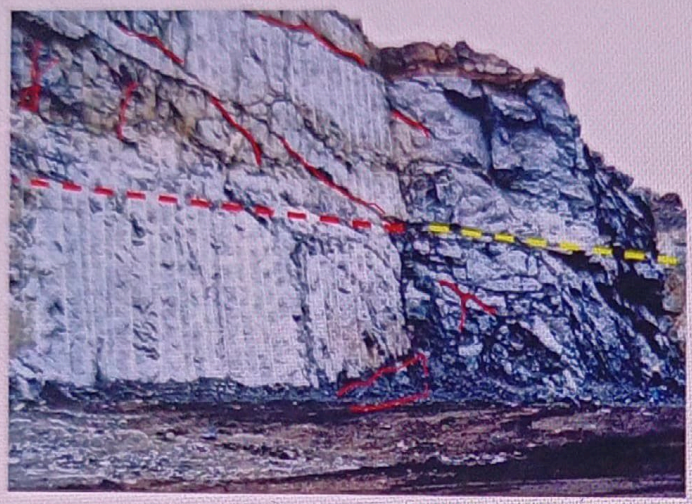
Reducing break

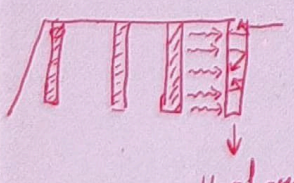
→ Perimeter blasting, normal blasting से ज्यादा expensive, time consuming है।



→ Use air deck to reduce blasthole pressure.
→ In water filled holes, use semi-rigid explosive cartridges
→ Burden hole dia के 25 गुना से ज्यादा नही होना चाहिए, 20 times is preferred.
→ Spacing → back row के blast holes की spacing ज्यादा होती है to get straight face.
→ blast hole dia का 25 से 40 गुना

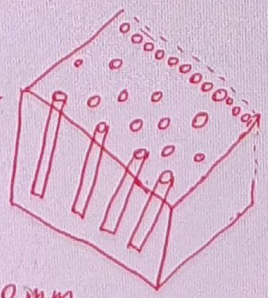
Methods of Controlled blasting.

① Line Drilling → Closely spaced holes drill करते है at the excavation limit



→ इन holes को empty रखा जाता है।

Uncharged hole.



→ Dia → 50 - 100 mm

→ Line drill के holes के बीच की spacing hole dia के 2 से 4 गुना के बराबर होता है।

→ Line drill के holes के बीच की spacing hole dia के 2 से 4 गुना के बराबर होता है।

→ Depth of drill → 10 m - 15 m.

Other methods of Controlled blasting.

1. Pre - splitting
2. Smooth wall blasting
3. Post splitting
4. Cushion blasting or trim blasting
5. Buffer Blasting.

→ Air decking →

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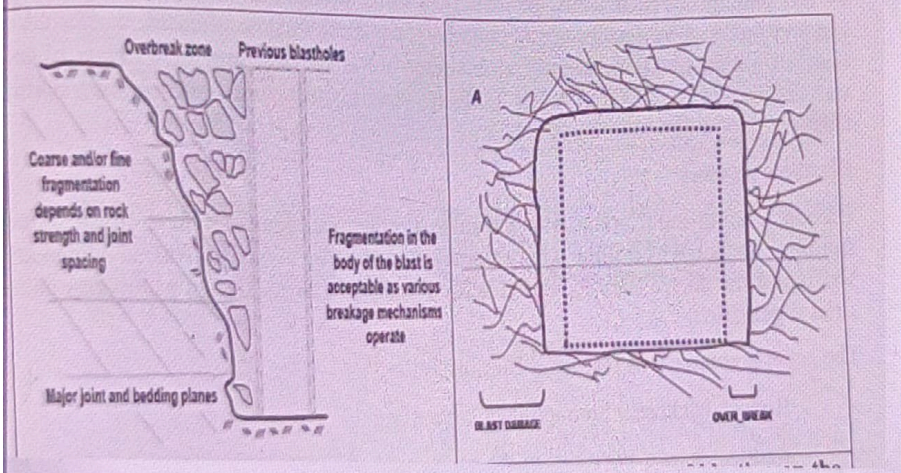
Controlled blasting

By – Devendra Singh Tomar

Controlled blasting

- Result additional tonnage to be removed and transported from the excavation site.
- Requires back filling of the over break portion to obtain the designed contour by consuming cement concrete etc.
- Requirements of additional expensive and time consuming roof control measures can be curtailed.
- When blasted below water level, pumping off water and sludge becomes additional burden.
- Regular maintenance of the face/roof or sides add to cost of manpower etc.
- Locking up of reserves due to decreased slope.
- If coal is left un-mined it leads to spontaneous combustion
- Depth of workings in majority of coal and non-coal mines, necessitated stability of the top benches.



Perimeter blasting

- The term is referred to all methods which have the aim of minimizing blast damage to the excavation perimeter by preventing the force of blast from continuing into the highwall
- General approach in perimeter blasting
  - Reduce back break
  - Reduce charge quantities
  - Drill extra holes in order to compensate for the reduced charge per hole
  - Arrange the initiation of the perimeter holes so as to obtain maximum relief of burden

Reducing backbreak

- Perimeter blasting is more expensive than normal blasting, time consuming and a precise operation, attempts should first be made to reduce backbreak by modifying the standard drilling and charging methods

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Reducing backbreak

- Perimeter blasting is more expensive than normal blasting, time consuming and a precise operation, attempts should first be made to reduce backbreak by modifying the standard drilling and charging methods.
- use an air deck to reduce blasthole pressure
- In water-filled blastholes, semi-rigid explosives cartridges should be used
- The effective burden on perimeter holes should not be greater than about 25times the blasthole diameter, preferably about 20 times.
- The best spacing between back-row blastholes is the largest spacing that gives a straight face. The spacing needs to be determined by trials; however it usually lies between 25 and 40 times the blasthole diameter.
- If possible drill angled rather than vertical blastholes at least for the last 3 to 4rows in front of the final wall. Angled blastholes tend to cause less damage to the crest behind the back row. Angles of 20 - 30 to the vertical are recommended. Be warned however that angled blastholes tend to produce more flyrock

Methods of controlled blasting

- **Line Drilling:-** Consists of drilling a row of closely spaced holes along the final excavation limits and not loading the holes with explosive.
- **Pre-splitting:-** Before firing the inner holes, the lightly charged perimeter holes are initiated simultaneously, creating a split between the blasting zone and the proposed sidewalls.
- **Smooth Blasting:-** The back holes are fired last as usual, relying on a reduced charge mass per hole for overbreak control.
- **Post-splitting:-** As with Smooth Blasting, but the back holes are simultaneously initiated in a separate blast.

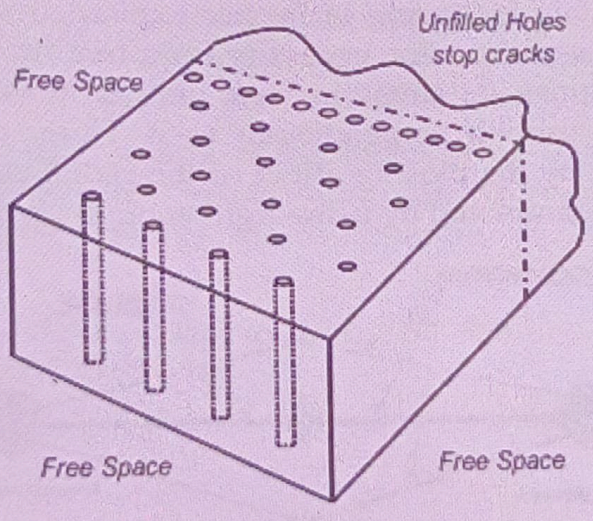

Figure 19.3, Showing line drilling

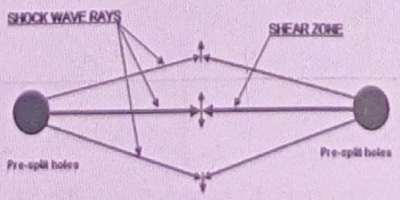

Figure 19.4, Theory of Pre-splitting

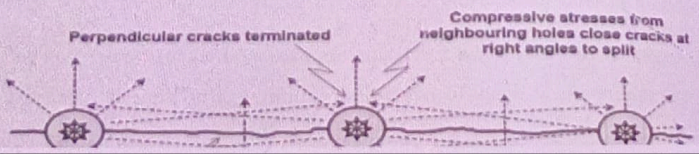

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Figure 19.3, Showing line drilling

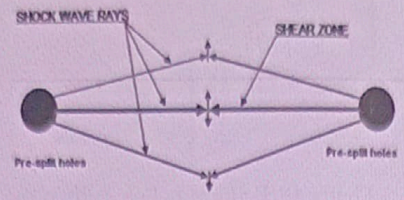
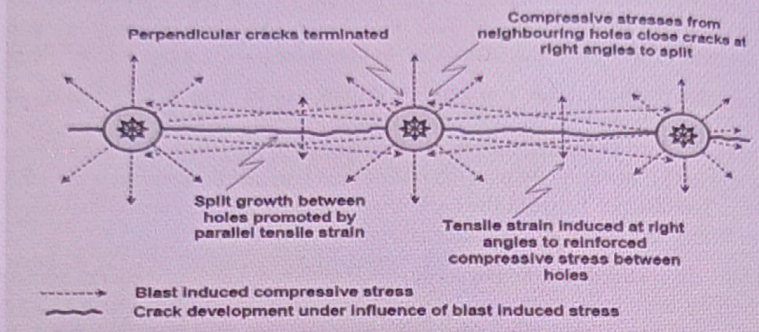


Figure 19.4, Theory of Pre-splitting



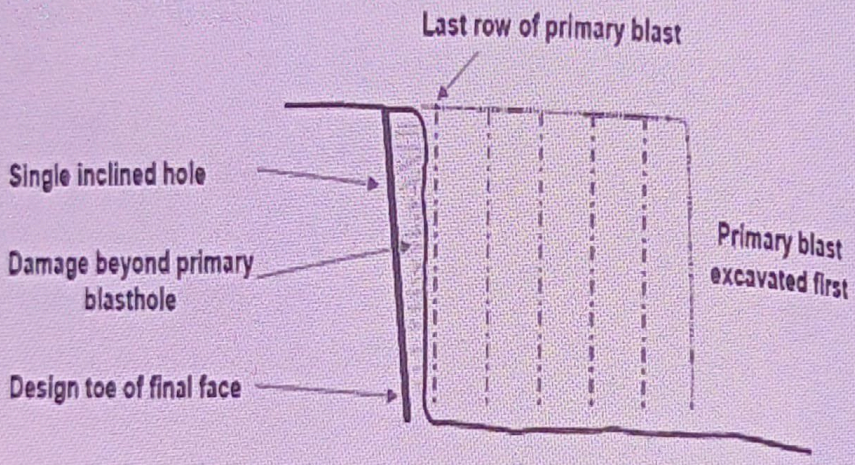


Figure 19.5, Post split (Trim) Blasting.

Line Drilling

- It consists of drilling a row of closely spaced holes along the final excavation limits and keeping holes empty.
- The line-drilled holes provide a plane of weakness to which the final row of blast holes can break and also reflect a portion of the shock wave generated from the blast.
- Hole dia – 50 to 100mm
- Line drilling holes are spaced two to four dia apart but are more closely spaced at the corners
- The maximum practical depth to which line drilling can be done is 10 to 15m
- The distance between the back row blastholes and the line of drill holes is between 50 to 75% of the normal burden distance

Pre - splitting

- Also termed as pre shearing
- It is a technique where a row of parallel holes closely spaced, along the excavation perimeter or final excavation are fired simultaneously prior to the primary blast.
- This creates a fracture line and reflective place at the periphery

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Pre - splitting

- Also termed as pre shearing
- It is a technique where a row of parallel holes closely spaced, along the excavation perimeter or final excavation are fired simultaneously prior to the primary blast.
- This creates a fracture line and reflective place at the periphery
- Pre-split holes are fired before any of the adjacent main blast holes.
- Crack between the holes is propagated by the light explosive charge.
- In a highly fractured rock, unloaded guide holes may be drilled between the loaded holes.

Smooth blasting

- The smooth blasting technique uses blastholes drilled on a reduced burden and spacing and charged with a reduced explosive charge
- It is done to improve the explosives distribution in the rock mass and therefore reduce the amount of damage to the final wall.
- Final walls from smooth blasting can be of a very high quality, especially if the rock mass is strong.
- Smooth blast rows may be used as the last row of a production blast to produce a final wall or a separate cushion blast may be fired after production blasting in the area is completed.
- The best burden and spacing for the perimeter holes is determined from trials

Post splitting (Trim blasting)

- A row of closely spaced blastholes are drilled with a spacing to burden ratio greater than 1.
- All holes are charged with light, well- distributed charges and fired simultaneously using Detonating cord
- To avoid loss of blastholes through caving, post-splitting blastholes should be drilled after firing the adjacent production shot.
- However, backbreak from the previous blast can sometimes cause difficulties with drilling close to the face.
- Post-split blastholes are charged and fired in the same way as those for pre-splitting, so that the detonation tends to split the rock between the holes giving a smooth wall with minimum overbreak.

Smooth wall blasting

- The perimeter holes are fired last, to provide best possible profile of the excavation wall.
- They are adopted in underground tunnelling where hole dia, is always in the range of 32 to 51 mm.
- In these holes decoupled charges having 17 mm, and 25 mm respectively are used in 32 mm. and 51 mm. drill holes.
- The explosive has self centering devices.

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Decoupled charges

- These explosives are available in the shape of pipes
- These cartridges inside the borehole can be automatically centralized by their specially designed connectors
- Initiated by Detonating cord or instantaneous electric detonators
- Where a number of holes are to be fired portions should be delayed with MS delays

Air decking

- At the bottom of the hole a specific quantity of explosive is loaded and a large part of it remains empty (except for the stemming).
- When fired the rebounding shock waves produce a cleanly split rock.
- This technique of pre-splitting is now quite popular.
- In this method a single explosive charge (cap-sensitive primed) and a bore-hole plug (either a power plug , air bag, bore plug – chemically activated or a jute bag filled with sand is hung from the surface)

Advantages of air decking

- Improved high wall stability leading to better safety and percentage recovery.
- Reduction of tow on high walls.
- 40-50% cheaper than conventional method of pre-splitting.
- Best suited for 'cast blasting' in high dragline benches.
- Reduction of ground vibration levels.

Applications of air decking

- Fly rock control
- Tunnel over break protection
- Reduction of fines
- Blasting for dimension stone
- Ore waste separation
- Control of vibration

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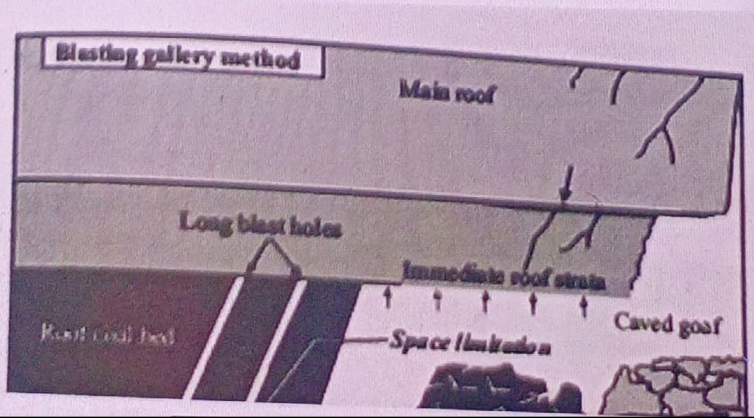
Blasting gallery method

- In this entire seam thickness can be excavated in one lift by drilling a set of holes in ring pattern with percentage of coal recovery ranging from 65 to 85%
- The basic principle of BG method is to be extract thick coal seams by drilling and blasting of roof and sides of gallery, which are driven at the bottom at the bottom of the seam at regular intervals.
- Ring holes are drilled in the rooms left between the two adjacent galleries in the roof and sides at regular Intervals varying between 0.75m to 1.5m by a crawler mounted JUMBO drill.
- Blasting is done using explosive cartridge separated by inert spacers and detonating fuse, so that the explosive spreads all along the length of the holes.

- Load Haul Dumpers (LHD) with remote control carry out loading of coal enabling the operator to stand under the supported roof and operate the LHD
- The development galleries are driven at the bottom floor of the seam.
- It is important that the correct size of rise/dip and rooms are maintained to avoid roof control problems during the retreating of the panel.

Advantages of BG method

- Full thickness of the seam can be extracted in a single lift.
- Higher percentage of extraction i.e. 75-85.
- Capital investment is nominal when compared to longwall project.
- Easy to train the man power and easy maintenance of the equipment.
- Extraction is carried under fully supported roof i.e. with remote controlled LHDS.
- Safety of the workmen can be fully ensured. This method can be also be adopted in virgin/developed seams.
- Most of the equipment and spares are indigenously available. Loss of production is minimum while shifting the equipment.
- This method is highly flexible as several units are in operation in a district Even if one of the units is under break down, production from the district will continue to come.



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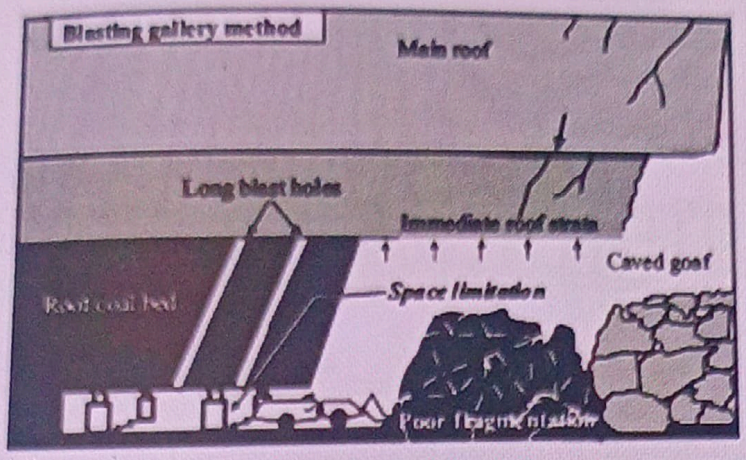


Figure 9.6, Blasting Galley Method

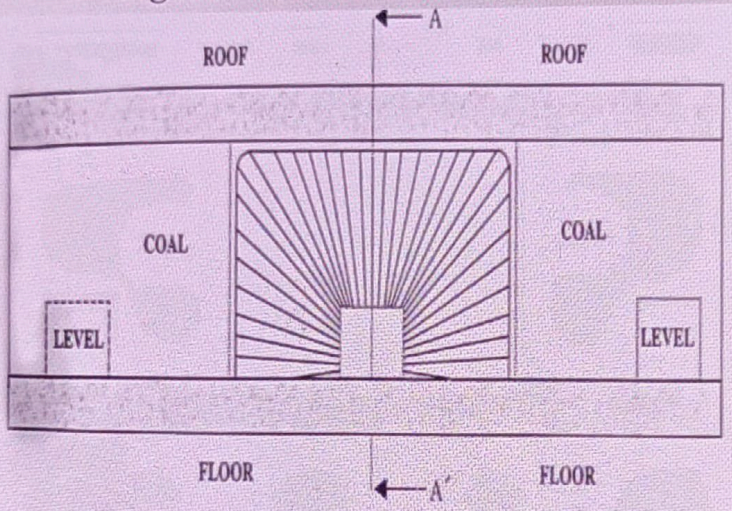
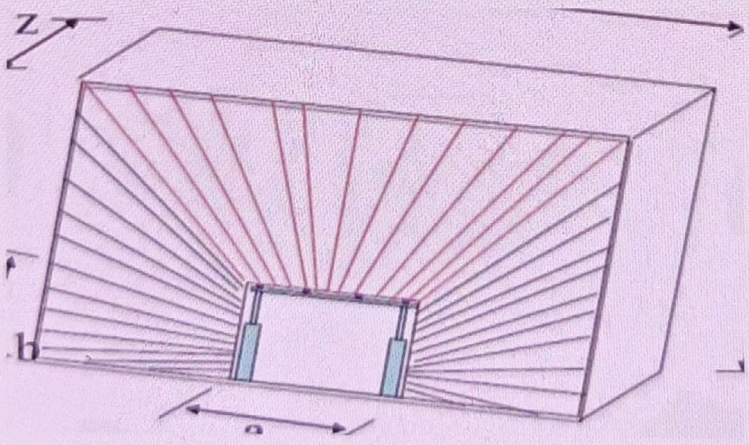


Fig. 2.2: Ring pattern of holes in Blasting Gallery (BG) method



Limitations of BG method

- This method is not suitable for gassy mines and seams.
- Most suitable for degree – 1 gassiness
- The method is suitable only for gradient more than 1 in 5 to allow easy movement of tyre mounted LHDs and crawler mounted electro-hydraulic jumbo drills.
- Though the percentage of extraction is around 75-85, still coal left in the goaf is likely to create spontaneous heating.

Decking

- By incorporating one or more inert material segments in the explosive column, the column can be divided.
- This helps in appropriate charge distribution in hard strata where better energy distribution is required.
- This reduces the ground vibration level also.
- Where non-electric delay is available, the different decks are blasted with different delay timings and thus charge/delay can be reduced significantly.
- The recommended 'deck thickness', is about 6 times the diameter of the borehole.
- Use of 'gas bags' as decking material in place of drill cuttings is a recent innovation.

- The Indian mines 'gas bags' are now being used on a trial basis and initial results are encouraging.
- With 'gas bags', 'air gap' decking can also be introduced in the explosive
- In bulk SMS and ANFO charging 'decking' is not recommended.
- But with 'gas bags' as 'decking material', decking in bulk charging could yield saving in terms of explosive quantity and explosive energy distribution.

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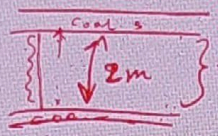
Pressure Arch Theory

By – Devendra Singh Tomar

Rock Mechanics & Roof Supports

→ जब beddding planes के बीच की दूरी 1.2 m से ज्यादा होता है तब rocks को massive rock कहते है।



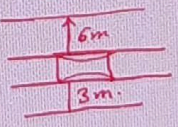
→ massive rock.

→ अगर distance 75mm से 1.2 m के बीच होता है तो bedded Rock कहते है।

→ अगर distance 75mm से कम होता है तो उसे flaggy rock कहते है।

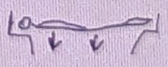
→ Rock Mechanics → It is the theoretical and applied science of the mechanical behaviour of rock and rock masses. It is that branch of mechanics concerned with the response of rock and rock masses to the force fields of their physical movement.

→ Coal mining areas में rocks के weight के कारण nearly 0.2 Kg/cm² का pressure exert होता है। यह हर एक metre की depth के साथ increase होता है।



→ Immediate roof → 6m above seam.
→ Immediate floor → 3m below seam

The Pressure Arch Theory.



→ Excavation के पहले lateral and Vertical pressures equilibrium की condition में होते है।

→ Vertical direction में Vertical compressive force होता है और sides से lateral compressive force रहता है।

→ UG roadway drive करने पर equilibrium disturb हो जाता है।

→ Vertical & lateral pressures का redistribution होने लगता है और नए forces वहाँ पर देखने को मिलता है।

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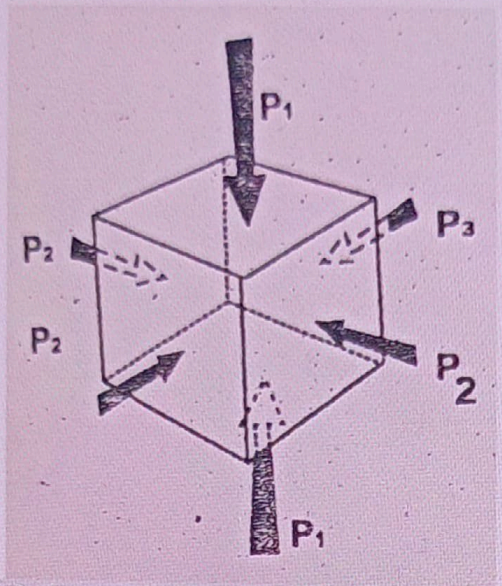
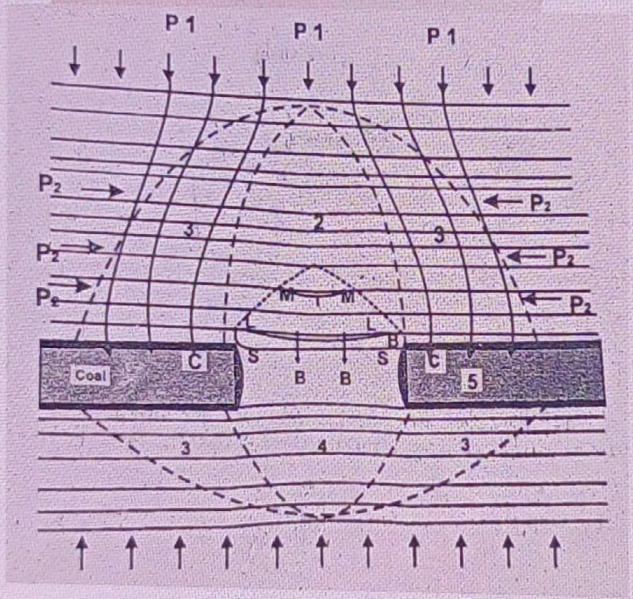
हो जाता है।

→ Vertical & lateral pressures का redistribution होने लगता है और नए forces वहाँ पर देखने को मिलता है।





→ Pressure के redistribution को Pressure Arch Theory कहते हैं।

B = Bending forces इसका magnitude excavation की width के साथ increase होता है।

P_2 = Lateral forces, इसकी intensity depth के साथ increase होती है।

P_1 = Vertical compressive force, it also increases with depth.

S = Shearing forces, coal & floor beds strong होने पर intensity highest होती है and weak होने पर lowest होता है।

C = Abutment Pressure

Abutment → lateral pressure को support करने के लिए बनाया गया structure.

→ Bord & pillar method of working में narrow roadway drive करने पर vertical compressive force

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→ Bord & pillar method of working में narrow roadway drive करने पर vertical compressive forces pillars पर deflect हो जाती है।

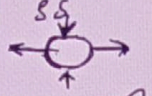
→ Immediate roof की rocks अपने weight के कारण downward direction में bend होता है and एक दूसरे से separate होने लगते है।

→ इसे bend separation कहते है।

→ higher strata का weight coal sides में transfer हो जाता है

→ Same time पर P_2 Pressure (side Pressure) rocks को roadway की तरफ push करता है।

→ Coal pillars के sides में shearing forces apply होता है।



→ Immediate roof AB, LL, MM and NN beam की तरह act करते है और अपने weight के कारण downward direction में bend होते है।

→ bed के lower layer में tension generate होता है जिसके कारण fracture generate होने का chance बढ़ता है।

→ Sagging और fracture को रोकने के लिए roadway को support किया जाता है।

Zones of Influence

Zone-1 → Immediate roof में bed separation due to bending forces.

Zone-2 → bed separation due to gravity

Zone-3 → Horizontal & vertical pressure, excavation के पहले के जैसे रहते है।

Zone-4 → Floor heaving show करता है। but bed separation नही होता है।

Zone 5 → horizontal stress release होने के कारण pillar sides, gallery की तरफ bulge होते है।

Arch के बाहर strata का weight coal pillars carry करते है।

→ Dotted lines pressure arch or pressure dome को represent करती है।

→ Abutment pressure static pressure से ज्यादा होता है।

→ Coal pillars में जो pressure आता है वह floor में transfer होता है।

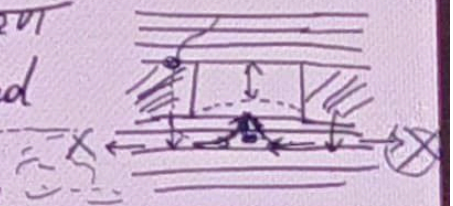
→ Dotted lines pressure arch or pressure dome को represent करती है।

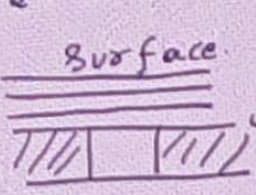
→ Abutment pressure static pressure से ज्यादा होता है।

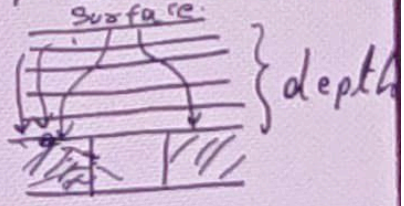
→ Coal pillars में जो pressure आता है वह floor में transfer होता है।

→ अगर floor strong नही होता है तो वह heaving show करेगा and gallery height reduce होगा।

→ Greater depths पर pressure बढ़ने के कारण coal abutment pressure को withstand नही कर सकता है और अगर pressure coal की crushing strength से ज्यादा है तो इसके कारण coal pillars crush हो जाते है।



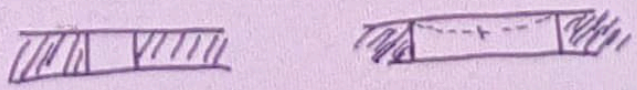




→ Wide excavation के कारण bending forces बढ़ जाते है और इन्हे artificial support से control किया जाता है।

→ अगर इसे regular check नही करेंगे तो immediate roof और अधिक bend होगा और समय के साथ इसमे Cracks develop होंगे जिनके कारण roof rock break हो जाएगा।

→ Width of maximum pressure arch → Roadway की maximum width जिसके कारण roof का collapse surface तक होता है।



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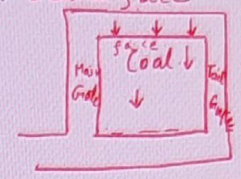
Pressure Arch In Longwall Working

→ Roof से higher excavated area के ऊपर एक bridge form करता है।

→ Bridge solid coal face से solid coal pillar तक Behind face होता है।



→ Timber or steel supports will support the immediate roof.

→ face advance के साथ arch space increase होता है and upper strata का load abutments पर बढ़ जाता है जब तक roof break नहीं हो जाता है।

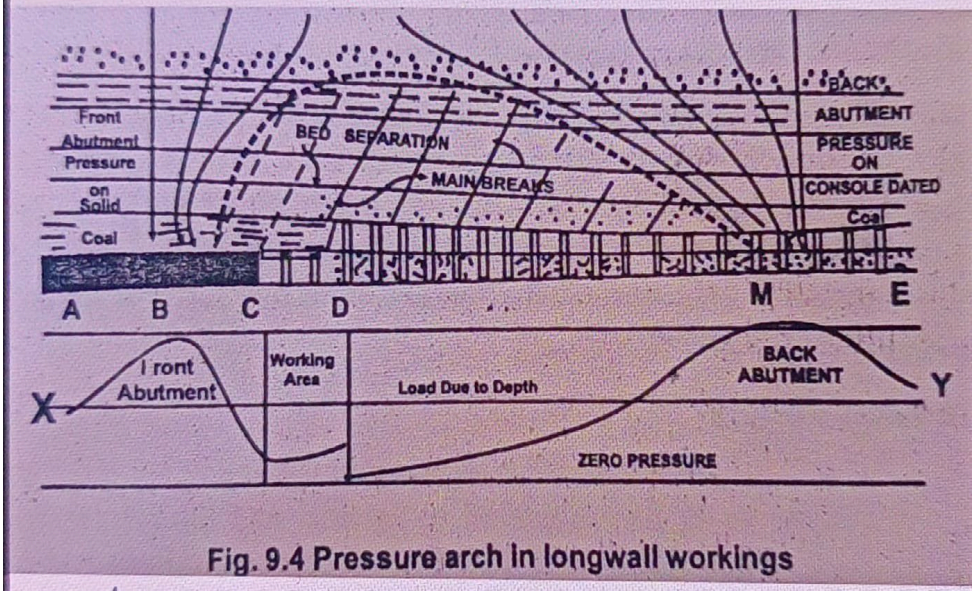
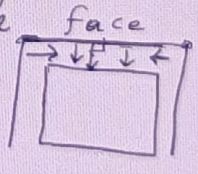


Fig. 9.4 Pressure arch in longwall workings

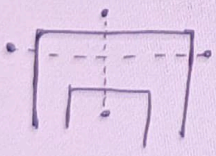
→ higher beds का weight face के आगे कुछ distance पर coal pillar पर आता है।

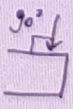
→ Pressure arch face advance के साथ shift होता।

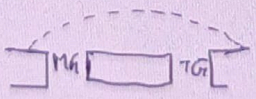
→ Longitudinal Pressure arch → face के right angle होता है।



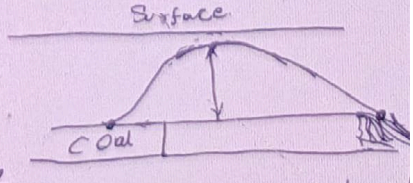
→ Transverse Pressure arch → पूरे face length के along होता है।







→ Pressure arch का apex or crest face length के comparison में काफी से कम 2 times height तक होता है।



→ अगर coal seam की depth Pressure arch की length के से काफी से ज्यादा हो जाता है

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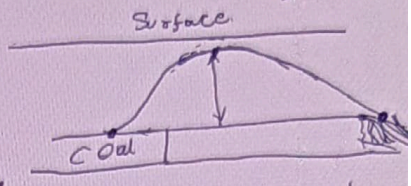
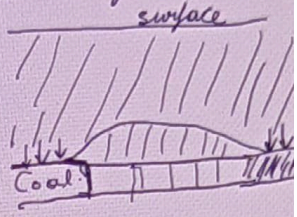
→ Pressure arch का apex or crest face length के comparison में कम से कम 2 times height तक होता है।



→ अगर coal seam की depth Pressure arch की length के दो गुने से ज्यादा हो जाता है तो Pressure arch के बाहर के rocks का weight abutments पर आ जाता है।



→ Depth कम होने पर pressure surface तक पहुँच जाता है। इस कारण से 100m से कम depth में roof control में problem होती है।

→ UG rocks को उनके weight के equal load देते हैं इसके लिए cores को lab में compressive strength पता करने के लिए लाते हैं।

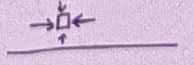
→

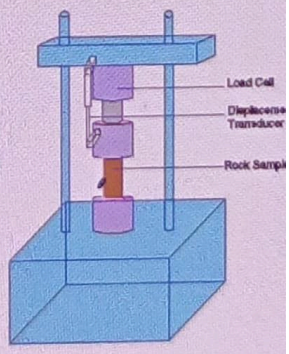
Uni-axial compressive strength Test.

→ Specimen को 2 plates के बीच में रखकर compress किया जाता है। यह rock mass की सिर्फ मजबूती बताता है।

→ Rocks की compressive strength से ज्यादा tensile strength होती है

→ Compressive strength lateral stress के कारण increase होता है।





Tri-axial Compressive strength test.

→ इसमें rock को सभी sides से hydraulic pressure की help से lateral pressure से compress करते

→ यह cylindrical specimen पर perform करते हैं।

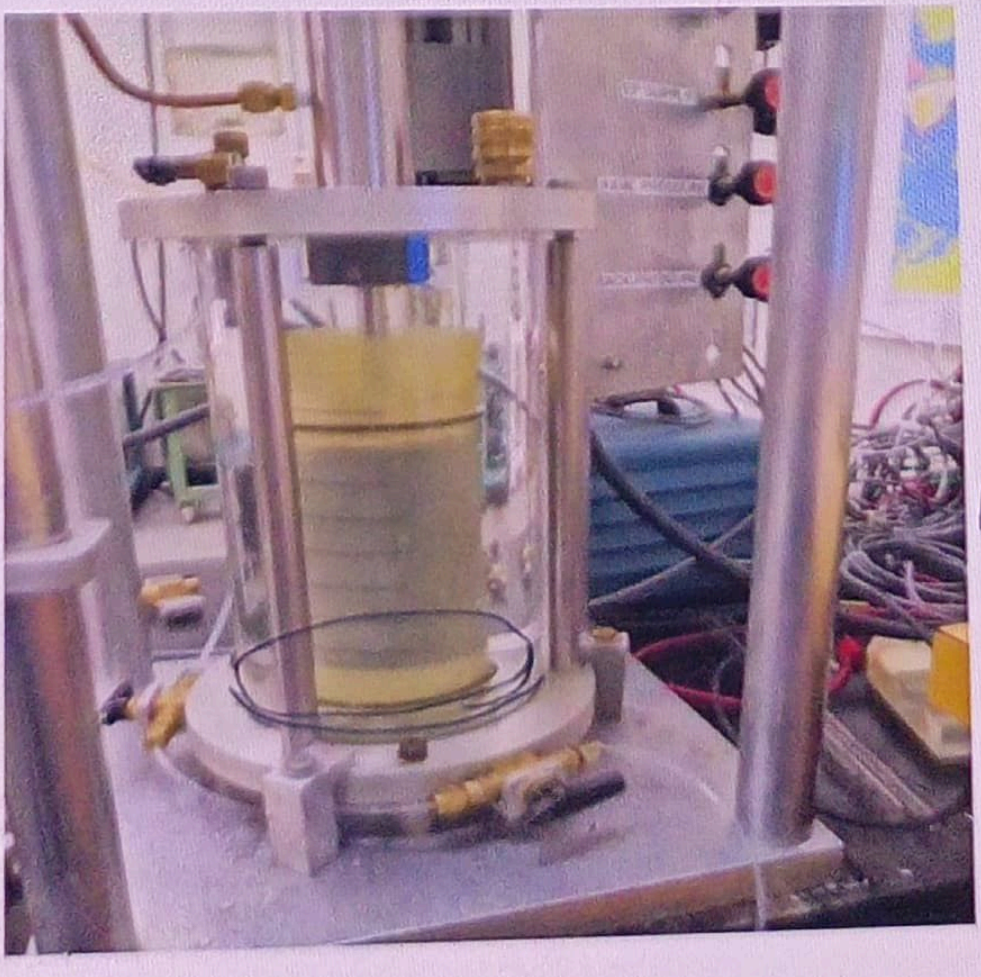
→ Specimen को cylindrical steel chamber में रखते हैं

→ length / dia ratio = 2 : 1

→ Lateral pressure by hydraulic oil & vertical pressu

Tri-axial Compressive strength test.

→ इसमें rock को सभी sides से hydraulic pressure की help से lateral pressure से compress करते हैं
→ यह cyindrical specimen पर perform करते हैं।
→ Specimen को cylindrical steel chamber में रखते हैं
→ length / dia ratio = 2 : 1
→ Lateral pressure by hydraulic oil & vertical pressure (axial) by testing m/c
→ Specimen dia - upto 54mm, length → upto 150 mm.
→ Pressure vessel internal dia → 140 mm.



20,000 psi
↓
138 MPa

heater
↓
upto 200°C
within
4 hrs.

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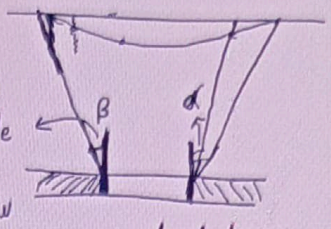
Subsidence

→ UG excavation की boundaries से जब fractures surface तक पहुँच जाते हैं उसे subsidence कहते हैं।



β = angle of draw
α = angle of fracture

→ Angle of draw → workings के edge के vertical line से subsidence area के edge तक का angle of inclination इसके आगे measurable subsidence नहीं होता है।

→ Angle of fracture → वह angle जहाँ पर strata break or fracture होता है। working के edge के vertical line से point of max.m tensile strain तक का angle of inclination

→ horizontal strata में angle of draw 35° होता है।

Factors Affecting Angle of draw.

1. Nature of superincumbent strata.
2. The existence of faults and their positions.
3. Cleavage or natural jointing of faces.
4. The thickness of the seam.
5. The method of working & packing
6. The dip of the beds and the direction of working in relation to it.
7. The depth from the surface
8. The surface contour.

→ **Superincumbent Strata**
- Harder the strata, smaller the angle of draw.
- softer the strata, steeper the angle of fracture
- More the angle of draw, flatter the line of fracture
- Watery strata में fracture ज्यादा होता है।

→ **Influence of faults.**
- Fault strata की continuity में break होता है।
- Fault plane के कारण angle of draw is more.

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→ Influence of faults.

- Fault strata की continuity में break होता है।
- Fault plane के कारण angle of draw is more.
- Fault plane अगर working के parallel होता है तो movement is more.
- Parallel नहीं होने पर fracture naturally break होते हैं।

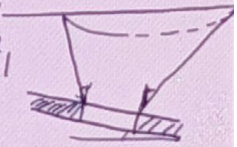
→ Cleavage

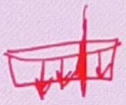
- Line of advance अगर joint के parallel है तो angle of draw reduce हो जाएगा

→ Dip of seam and direction of advance.

- Rise side में angle of draw कम होता है।
- Dip side में angle of draw ज्यादा होता है।
- Acc. to O'Donahue Critical angle of dip may be 24°
- Angle of draw on rise side.

$$\beta_r = a - \left(\frac{a}{24} d\right)$$





- Angle of draw on dip side.

$$\beta_d = a + \left(\frac{24-a}{24} \times d\right)$$

where,

a = angle of draw in horizontal working.

d = dip of the seam.

- Steep seam (dip > 24°) में angle of draw इस relation follow नहीं करता है।

→ Thickness of the seam.

- Caving method से करने पर subsidence and angle of draw बढ़ जाता है।

→ Method of working and stowing.

- Any method of working with stowing results ind[illegible]

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→ Method of Working and stowing.
- Any method of working with stowing results ind reduced subsidence.
- Angle of draw same रहता है

→ Depth of the seam.
- Increased depth पर greater area is affected by subsidence.
- Angle of draw will remain same

→ Surface Contour.
- steep slopes में surface damage is more
- β is more

Critical Width of Extraction

→ Surface पर किसी भी point पर पूरी तरह से subsidence तब होता है जब working critical area में करते हैं।

→ This area is obtained when lines of draw meet at the surface

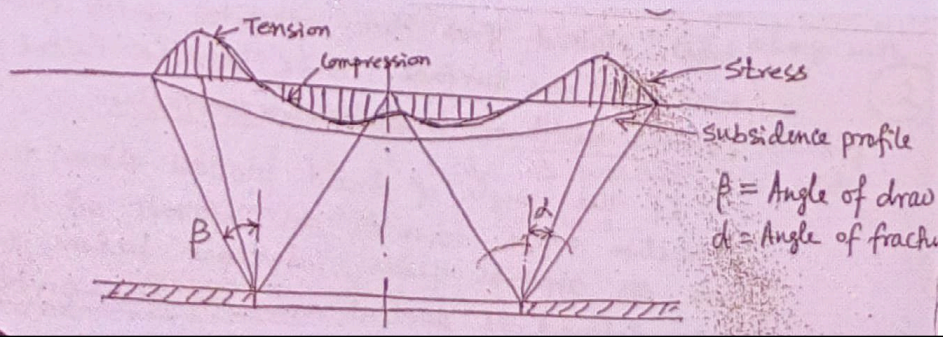
→ This is also called full area or critical width of extraction.

Sub Critical Width of Extraction

→ अगर angle of draw की lines surface के नीचे meet करती हैं तो उस case में उसे partial area or sub-critical width of extraction कहते हैं।

Super Critical width of Extraction

→ जब angle of draw की lines surface से ऊपर meet करती हैं तो उस case में उसे super critic area or super critical width of extraction कहते



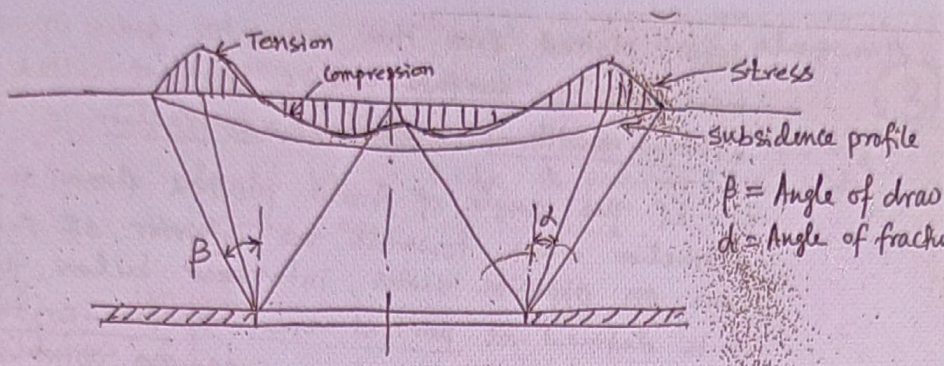


Fig. 1 : Critical width of Extraction

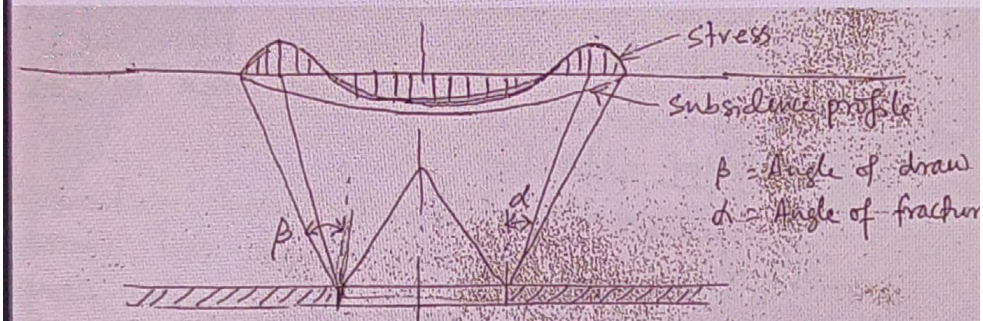


Fig 2 : Sub-critical width of extraction

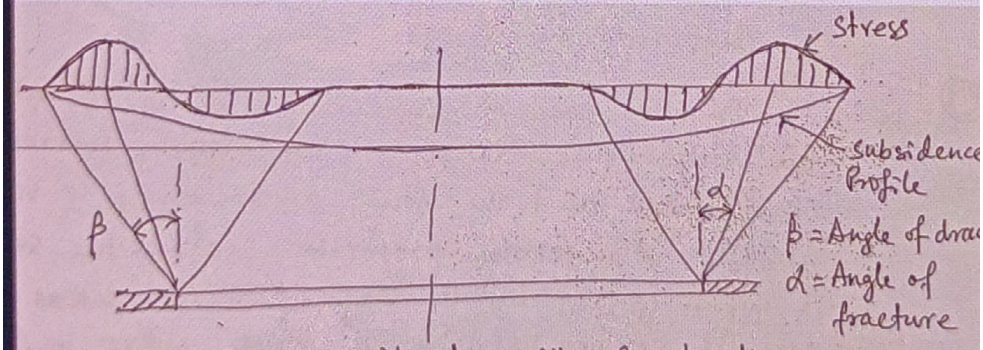


Fig. 3 : Super-critical width of extraction

Types of Subsidence

① Continuous subsidence

→ Smooth surface subsidence

→ In thin, horizontal or flat dipping orebodies में होता है।

→ And orebody is laid by weak sedimentary strata

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Types of Subsidence

① Continuous subsidence

→ Smooth surface subsidence.

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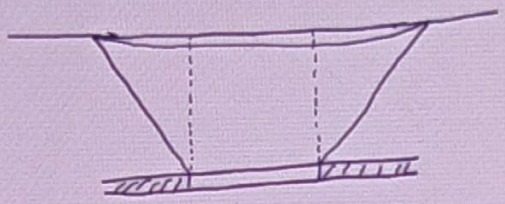

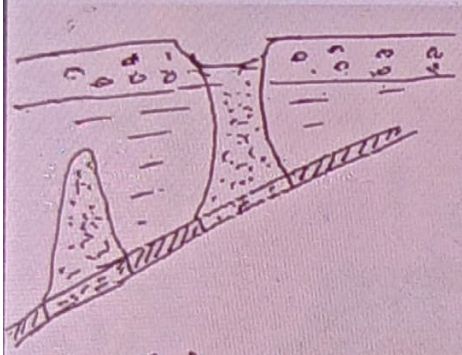

Fig (a)
Crown hole

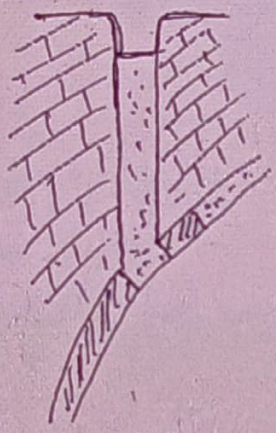

Fig. (b)
Chimney caving

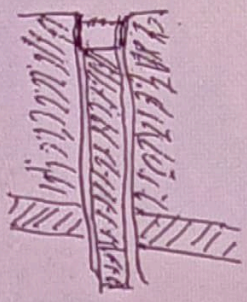

Fig (c)
Plug subsidence

(i.e. Sink hole) : i

② Discontinuous Subsidence.

→ Crown holes → It arises from the collapse of roofs of generally abandoned and shallow open workings.

→ Chimney Caving → Movement of an unsupported mining cavity. It is of same size & shape of the original excavation.

→ Plug subsidence → Sudden chimney / Column formation due to structural features like dykes or faults.

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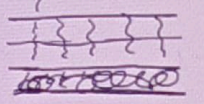
Properties of Various Types of Roofs

→ Immediate Roof → It consist of coal, sandstone, shale or fire clay.

→ अगर seam की thickness 3m से ज्यादा है तो roof में coal मिलेगा अगर floor के पास काम करते है

→ Coal roof एक अच्छा roof होता है और समय-समय पर dressing करके hanging coal को गिराने से कोई खतरा नही रहता है।

→ Compressive strength → 1.5 tepcr sq. inch.



→ Sandstone roof → Break होने के पहले हल्का सा bending show करता है। and fracture के पहले पर्याप्त warning देता है।

→ Mining के हिसाब से सबसे best roof होता है।

→ Crushing strength → 13.5 Kg/mm²

→ Shale Roof → Unreliable and most treacherous roof. Collapse होने के पहले warning नही देता है।

→ Expose होने पर atmospheric action के कारण जल्दी ही टूटने लगता है।

→ हर कुछ समय के अंतराल में layer by layer break होता है।

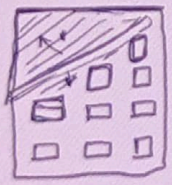
→ अगर seam thickness पर्याप्त है तो इस case में 0.6m की thick coal roof में छोड़ देते है and depillaring के समय extract कर लेते है।

Types of sandstone Roof

① Laminated Roof → Sandstone and coal से बनी Roof

→ Support withdraw करने पर local roof fall occurs after 4 to 10 hrs.

→ fall होने पर coal pillars को local weight से relief मिलता है।



② Massive Roof → It consist pure sandstone

→ यह roof break होने के पहले warning नही देता है।

→ Depillaring area में roof supports withdraw करने पर भी longer period तक withstand करता है

→ इसके कारण heavy air blast का खतरा बना रहता है।

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Table 1

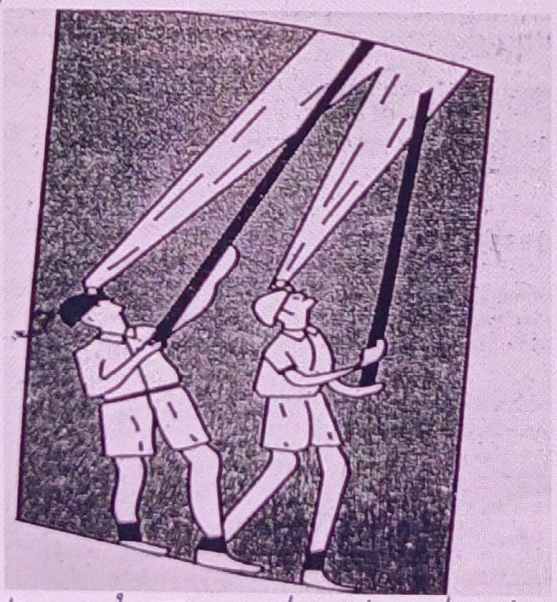
A is surface with multi-storeyed pucca buildings.
B is the surface with one-storey building, main river like Lamodar and main railway line.
C is the surface occupied by *kutcha* buildings, jores or tanks.
D is the surface on which sidings and roads are laid.
T is the thickness of the seam being extracted in (in meters).

Method of extraction.	Safe cover for surface			
	A.	B:	C.	D.
1. with caving	60 × T	52.2 × T	45 × T	37.5 × T
2. With hydraulic sand-stowing (Assuming 15% shrinkage)				
3. With dry packing (assuming 30% shrinkage).	9 × T	7.5 × T	6.8 × T	5.6 × T
4. Splitting of pillars to the extent that pillars left contain at least 40% of pre-mining coal content upto 60 m depth, and hydraulic stowing of decoaled voids. For every 60 m extra cover, the percentage of coal should be increased by 1%.	5.5 T	5.5T	4T	3.5T

Testing of Roof

→ Testing is done by.
① Visually with the help of a strong light
② By hearing sound of the roof or a propset when tapped with a stick.
③ By feeling the vibrations when the roof is tapped with a stick

→ Visual test aims at :-
① Detecting cracks in roof & sides
② signs of weight on supports such as
- lids की bending
- Burr of tapered end.
③ Water percolation from roof.



→ stick से tap करने पर good roof and sides में ringing sound आता है।
→ Dull or dummy sound आने पर support देना है।
→ Testing करते time official rise side में खड़े होकर करेंगे। क्योंकि bad roof होने पर गिर सकता है।
→ 2.5m से ज्यादा height की gallery में bamboo के testing end में iron लगा कर test कर सकते हैं।
→ Height 2m से ज्यादा है तो bad

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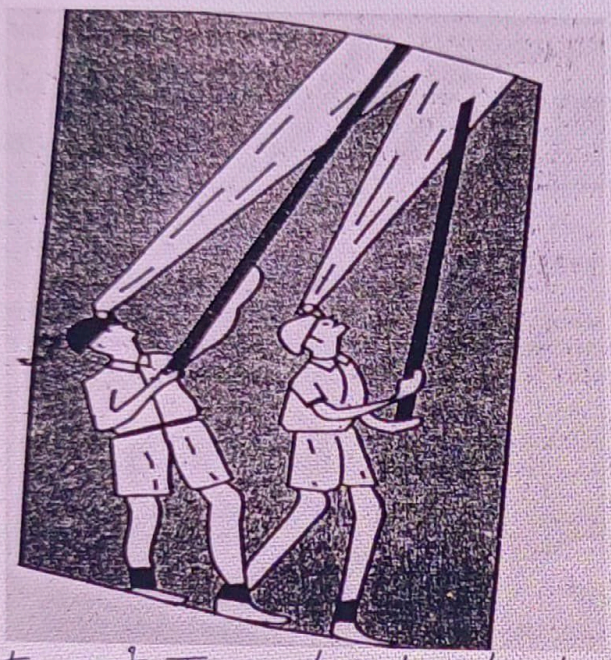
① Visually with the help of a [illegible]
② By hearing sound of the roof or a prop set when tapped with a stick.
③ By feeling the vibrations when the roof is tapped with a stick

→ Visual test aims at :-
① Detecting cracks in roof & sides
② signs of weight on supports such as
- lids की bending
- Burr of tapered end
③ Water percolation from roof.



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→ 2.5m से ज्यादा height की gallery में bamboo के testing end में iron लगा कर test कर सकते हैं।
→ अगर shale bed की thickness 0.3m से ज्यादा है तो bad roof होने पर भी ringing sound देता है। सावधानी रख
→ Prop को tap करके भी test कर सकते हैं।
→ Vibration test में experienced men roof में हाथ रखकर tap करते हैं and Vibrations को feel करके test करते हैं।

→ Vibration testing is done when height is not more tha 2.2 m.
→ 5m की height वाली roof में electric torch से visual test करते हैं।
→ 5m की height वाली roof में Vibration test करने के लिए एक worker roof को bamboo से दबा कर रखता है and दूसरा worker tap करता है तो पहला worke Vibrations को feel करता है।

Timbre support

By – Devendra Singh Tomar

→ It is a cheap and easily available material.

→ Height of Gallery → Dia of prop at thick end

1.2m to 1.8m	→	100mm – 125mm.
1.8m to 2.4m	→	150mm – 175mm
3m and above	→	175mm – 225mm

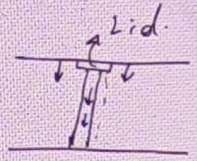
→ Metal mines में timber prop को still करते हैं

→ Mines में use होने वाले timbers को 2 disease होते हैं,

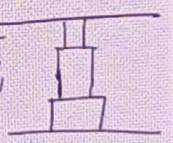
① Dry Rot
② Wet Rot

→ Diseased timber soft and weak होता है and fungus भी लग जाता है,

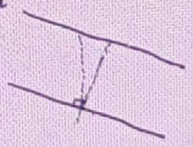
Setting of Props



→ अगर load timbre prop के length के parallel act करता है तो prop strongest होता है,

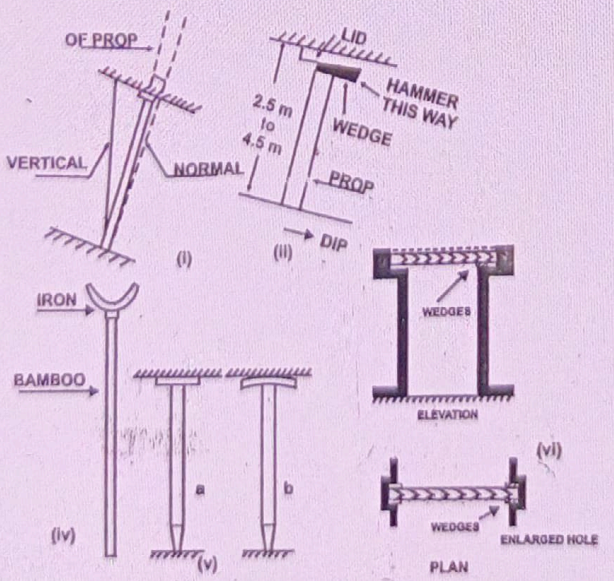


→ अच्छे से load yield करने के लिए prop को:-
(a) foot & top पर tapering करना है,
(b) prop के top पर lid लगा होते हैं,



→ flat seams में prop को vertically erect करते हैं,

→ Inclined seams में prop को seam के dip के normal रखते हैं,



→ Underset Prop → Prop को जब seam के vertical and normal axis के बीच में

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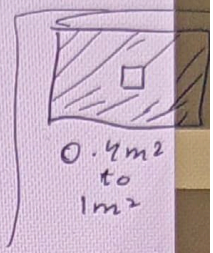
(V) PLAN

→ Underset Prop → Prop को जब seam के vertical and normal axis के बीच में रखते हैं।

→ Prop should be set on solid floor and not on loose packing.

→ if it has to be set on loose floor, place it on a flat base piece.

→ Dimensions of flat base piece
Thickness → not less than 5mm.
width → not " " 25 cm
length → " " " 0.9m.



0.4m² to 1m²

Roof height upto 2.5m

- Prop is held upright in the place where it is to be erected, a lid placed on top of it (not nailed), and a wedge is hammered between the lid and the prop to tighten the lid against the roof and the floor
- Generally for this thickness, the lid and wedge are not used as two separate pieces, but the lid is so made (slightly tapering along the length), that it serves the purpose of a wedge also.
- If there is any crack or slip which needs support, the lid should be placed across the crack or slip.
- A lid serves to distribute the resistance of the prop over a slightly wider area than its cross-section, to prevent penetration of the prop into the roof, and to indicate the load on the prop.
- It also helps easy withdrawal of the prop.
- Wedges are used to tighten the prop against roof and floor.
- The lids and wedges should be at least of the same width as the dia of the prop of a minimum thickness of 80mm and of a length of 0.5m

Roof height of 2.5m to 4.5m

- **1st Method**
- The position of the bottom end of the prop on the floor corresponding to the place in the roof to be supported is marked by a plumb bob suspended by a bamboo.
- The prop is held upright by 2 or 3 timber helpers.
- The timber man standing on a high stool or a ladder places the lid and a wedge is hammered on a position.
- **2nd Method**
- A lid is attached to the prop by nails and a hole is made nearly 25mm deep in the floor where the bottom end of the prop is to remain after erection.
- The prop, laid on the floor with the bottom end in the hole, is made upright, the hole preventing the prop from slipping
- The prop is held in position by timber helpers and one timber helper levers up its bottom end by a crowbar bringing the lid in contact with the roof.
- A wedge is then hammered between the prop and the floor to tighten the lid against the roof.

Roof height above 4.5m

- The lid is fixed to the prop by nails.
- The prop is raised upright in its position of erection by helpers, with the help of a fork or by a rope tied to the prop with a special knot which releases the rope when pulled.
- The prop is tightened up by the timber man by hammering a wedge at the bottom

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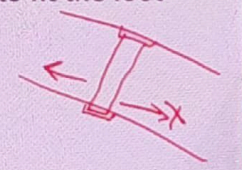
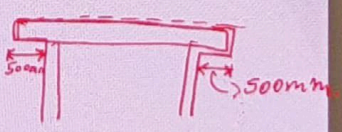
- The prop is tightened up by the timber man by hammering a wedge at the bottom
- In inclined seams steeper than 1 in 5 it is usual to fit the foot of the prop into a stamp hole in the floor



Timber bars



- Bars act as beams.
- A timber bar is placed in the holes of minimum depth of 500 mm in the side of a coal pillar if the sides are strong
- If the sides are weak, the bar is placed on vertical props.
- If the bar is circular in cross-section, the top end of the prop should be hollowed out to fit the contour of the bar.
- Alternatively the bar may be flattened at each end so that the ends can rest on flat ends of the props.
- The bar should always be tight against the roof and should offer the maximum area of contact against it.
- The side of the bar towards the roof is chopped flat for this purpose Flat wooden laggings are also used if the roof is uneven.

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MINING GYAN

Bar Supports

By – Devendra Singh Tomar

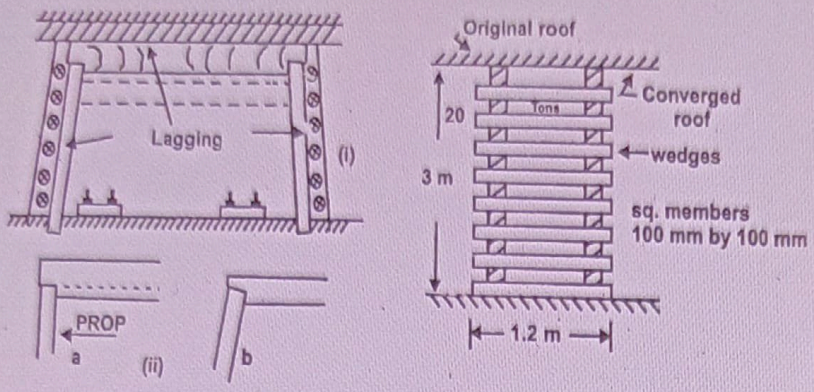
Safari support

- The conventional method of supporting galleries in coal mines is by means of wooden cross bars.
- For fixing these cross bars, holes are to be made in the coal pillars manually by crowbar.
- This is time-consuming and the whole operation of fixing one cross bar, this method takes about 2-21 hours.
- Therefore the supports lag much behind the working face.
- For quick setting of the cross bars, the manual cutting of holes in the coal pillars is eliminated by drilling holes with the usual coal drills and a support, known as safari support, is installed to support the roof.

- This support consists of a pair of clamps of mild steel on which a cross bar is placed to support the roof.
- Each clamp consists of an angle iron frame to which semicircular m.s. bracket is welded as a seat for the wooden coss-bar and in the angle iron two holes, 35 mm. dia. and 175 mm apart, are provided for two m.s. rods of 32 mm dia. 700 mm long.
- The two m.s. rods of each clamp are inserted into the holes drilled in the coal pillar. The cross bar is placed in position over the two brackets and tightened against the roof with wooden wedges.
- The complete operation of setting the support is completed in 15-20 minutes for each cross bar.
- The clamps can be easily recovered and used again for several times.
- The support stands the effects of blasting and the freshly exposed roof is supported in a short time after exposure.
- One of its applications is to support the split galleries in depillaring areas in thick seams and extract the floor coal, heightening the galleries upto 5 m.
- During extraction of stooks, wooden chocks are provided in the spilt galleries and later on the clamps are recovered completely for re-use.

Side Support

- Wooden laggings are placed tight between vertical props and pillar where the sides are weak and need support.
- Sometimes the timber set of prop and bar has to resist pressure from sides which tend to crush into the roadways.
- The props should be set at an angle of 14° to 20° off the vertical and the feet well sunk into the floor.
- An alternative method of resisting side pressure is to sink the props well into the floor and to reinforce the timber-set by an additional bar or stretcher.
- Which may be nailed to the props.
- As this reduces effective height of roadway, its use may not be advisable in roadways of less than 2 m height, used by basket loaders.



Support by wooden cog, chock or chockmate

- A chock, cog or chockmate is a combination of sleepers above one another in a criss- cross manner
- It supports a much larger stretch than a prop and is used in places where the roof is bad over a wide area and needs a substantial support.
- Cogs are also erected where main roadways have to pass through area having coal pillars of inadequate size.
- The term chockmate is generally used in metal mines.
- Cogs are required at goaf edges, at junctions of splits and galleries in depillaring areas in bord and pillar workings, and at break-off line at the goaf on longwall faces.
- Only rectangular sleepers, or alternatively, sleepers having their two opposite sides chopped flat, should be used.

- The minimum length of sleepers of a cog to support roof at a height upto 3 m may be 1.2 m but for a roof height in excess of 3 m it may be 1.5 m.
- The sleepers should have a minimum cross section of 100 mm * 100mm
- The cog should not be normally erected on loose floor or debris, but on natural floor or on secure foundation.
- The floor area over which the cog is to be erected may be excavated for a depth of 25 to 50 mm and should be made nearly flat in seams of mild inclination.
- Members of the cog are placed at right angles over the members immediately below in pairs.
- The chock is tightened against the roof by hammering wedges in it at a convenient height.
- When withdrawing a chock, withdrawal of such wedge loosens the chock and withdrawal of the sleepers becomes easy.
- The chock should be tight against the roof and this may be tested by hammering for looseness at the uppermost sleepers.
- In some cases a chock is erected in between four corner props.

- Such corner props are generally not necessary except
  - where the roof is very bad
  - at goaf edges of galleries
  - at junctions of galleries
  - if the floor is steeper 1 in 5

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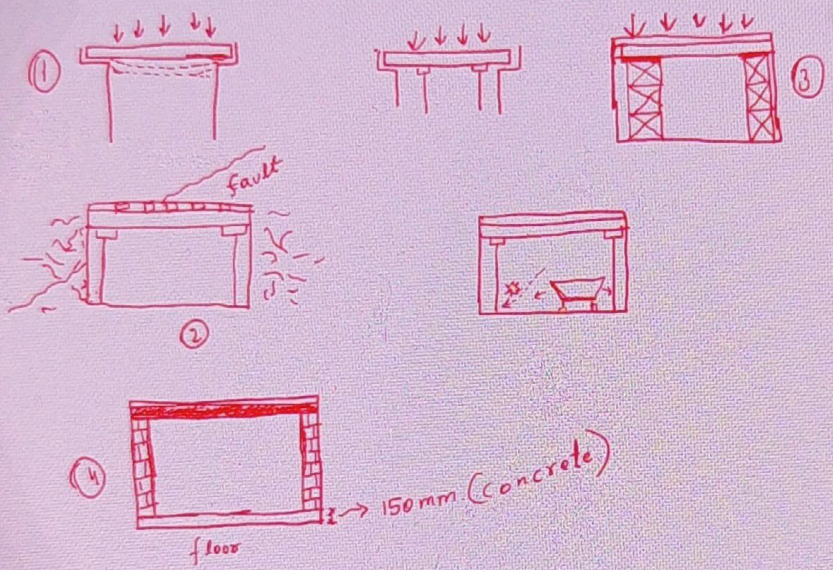
Support Roadway

- Where the roof of a roadway is bad over some distance bars resting in holes of coal pillars and tightened against the roof by wooden laggings may be erected at intervals of 2 to 3 m.
- If the coal pillars are not strong enough or the road is through a fault zone, the wooden bars are supported on timber props.
- Where the roof pressure is likely to be heavy bars may be supported on timber chocks.
- No props should be erected at such a place where they are likely to be dislodged by moving or derailed and runaway tubs.
- The bars may sometimes be placed on bricks walls constructed on solid foundation of coal floor with 150 mm layer of concrete at the base.



Systematic Timbering

- "Systematic timbering" is the term used for erecting supports in such a manner that the distances between supports are according to a specified pattern as laid down by the Manager and approved by the Directorate of Mines Safety
- Systematic timbering is essential in the district of bord and pillar workings where splitting of pillars or depillaring is going on, on every longwall working face, in every working in a disturbed or crushed ground (e.g. fault zone) and at other place where the D.G.M.S. may so direct.
- The type of supports to be erected, whether cogs, props, or bars are also specified in the order governing systematic timbering.
- In every case of systematic timbering, it is essential that additional supports shall be erected as and when necessary.
- Manager has to hand over copies of systematic timbering rules to all the supervising officials and has to post such copies at conspicuous place in the mine.

→ Who prepares Systematic timbering Rules?
Ans → Manager

→ Who gives approval to Systematic timbering Rules?
Ans → CIM / DGMS / DMS

→ Where does systematic timbering Rules apply in UG Mine
Ans → District of BLP working
→ Splitting Gallery
→ Depillaring area
→ Longwall working face.

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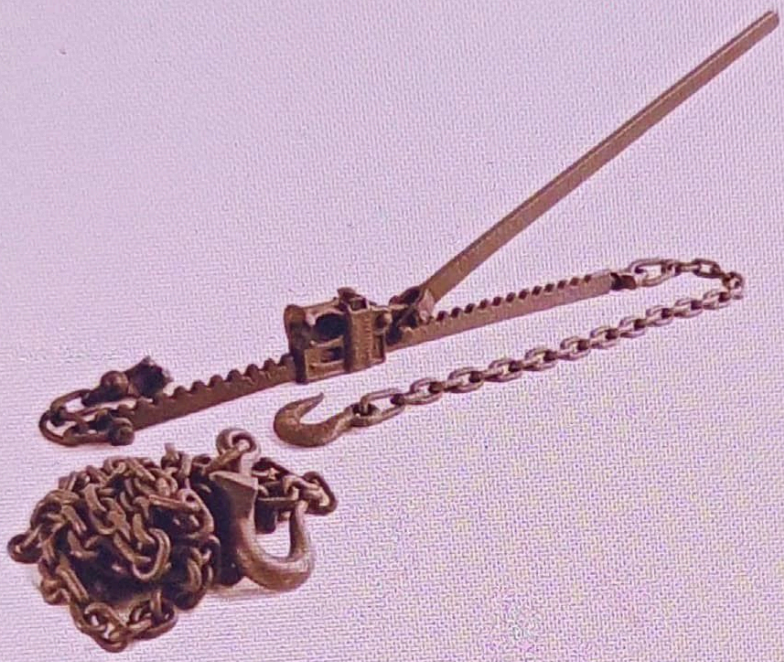
Ans → CIM / DGMS / DMS

→ Where does systematic timbering Rules apply in UG Mine?

Ans → District of BLP working
→ Splitting Gallery
→ Depillaring area
→ Longwall working face.
→ Fault Zone.

→ According to which rule cog, prop or bar support is done?

Ans → Systematic timbering rules.



Withdrawal of supports

- When props, bars or cogs have to be withdrawn it is prohibited by law to withdraw them by hammering.
- Suitable safety prop-withdrawer like the sylvester prop-withdrawer has to be used.
- It is an advantage to fix the chain C on the prop PG in such a manner before withdrawal that when the chain is pulled and is getting tightened, the prop receives a slight twist – on action which loosens the prop in its position.
- In the depillaring areas, a long chain is often required in place of the chain C.
- To avoid such long length, a flexible wire rope with steel core (e.g. 15 mm dia: coal cutting machine haulage rope having capels at both the ends may be used in conjunction with the usual 6 m long chain.
- Where the roof is high, a suitable anchor prop may not always be available for operation of prop withdrawer.
- In such case a piece of rail is fixed in a half metre deep hole in the floor. It serves the purpose of anchor prop.
- Alternatively, a strong bar fixed in the coal pillar may be used to serve the object.
- Care should be taken to see that the anchor prop or other props which provide safety to the timbermen operating the prop withdrawer, should not be dislodged by the prop under withdrawal when it is released.

→ Acc. to law withdrawal of supports shall not be done by?

Ans → hammer / hammering

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MINING GYAN

Iron & Steel supports

By – Devendra Singh Tomar

- Iron and steel are used in mines in the form of rigid and yielding props, beams and girders, reinforcement in concrete, corrugated sheets and roof/floor bolts.
- Discussed rails of 36 lbs. section or heavier greatly reduces fire risk in mines.
- Steel props used in the mines are:-
  - rigid props
  - yielding props
- An ordinary H section steel girder of suitable length with the web cut away and flanges turned over at one or both ends is the common type of a rigid prop.
- If the props in use bents it can be straightened by hydraulic pressure
- Timber core through major length and extending 25 to 40 mm beyond the steel pipe at either end.
- The timber core yields to some extent to the roof pressure and gives indication of roof, weight.

Questions

- Which type of rails are used in mines to reduce the risk of fire?

Ans. 36 pounds (16.3 kg) or heavier

- What must be used in steel girders to avoid bending?

Ans. Timber core

- What length of timber core shall extend beyond the steel girder?

Ans. 25mm – 40mm

- What is used in the steel girders to get the early indications of roof weight?

Ans. Timber core

Advantages of rigid steel props over timber

- A row of steel props offers uniform resistance if properly set.
- A steel prop has a greater ultimate strength than timber.
- Recovery of steel props and frequency of its re-use is greater.
- If buckled, it can be straightened and re-used but a timber prop once broken cannot be re-used except as lagging.
- A steel prop does not deteriorate to the extent timber does; timber decays in a number of ways, particularly by dry rot

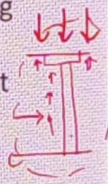
- A steel prop does not deteriorate to the extent timber does; timber decays in a number of ways, particularly by dry rot.
- They are incombustible.

Disadvantages of steel props

- Large props are difficult to tighten against the roof and may, therefore be knocked out.
- A large manpower is required for handling them.
- Wooden props give warning of heavy weighting, which steel props do not.
- A simple joist prop cannot be used in seams of varying thickness.
- Cutting of a long prop and turning its flanges cannot be done at the site of erection.

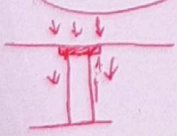
Terminologies related to props

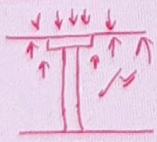
- **Setting load –** It is the load which is provided by the setting device to the yielding prop for the purpose of support and also can resist the lateral pressure of the face machinery. It must not be less than 4 tonne in a seam of moderate thickness. This load does not affect the yield load.

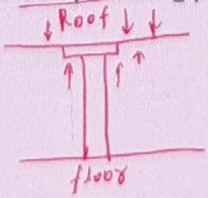


- **Yield load –** The maximum load that a prop can resist and above that load upper member of the props begins to slide.
  - Hydraulic prop – 20 tonne or 30 tonne
  - Friction prop – Its yield load depends on the force with which it's clamps are tightened.

- **Load bearing capacity –** The load at which prop reaches its elastic limit or begins to bend.
- **Characteristic curve or load yield curve –** It is a graph which represents the behaviour of prop under load.
- **Early bearing props –** The yielding props which accept the maximum load with a minimum yield load. It is one which is capable of building up of maximum load with a minimum of yield, thus reducing to a minimum both convergence and bed separation. Hydraulic props are early bearing props.







Questions

- What is the another name of characteristics curve?

Ans – load yield curve

Questions

- What is the another name of characteristics curve?

Ans – load yield curve

- In the load yield curve x axis represents _____ and y axis represents _____

Ans – yield load and load on the prop

- Due to which load bending can be observed in a prop?

Ans – load bearing capacity

- After the load bearing capacity of a prop which of the following observations are made due to further load?

Ans – bending and it reaches to the elastic limit

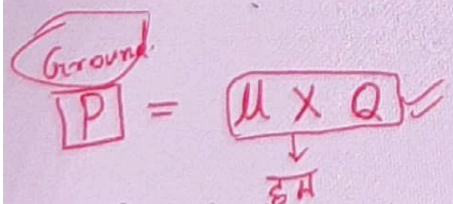
Questions

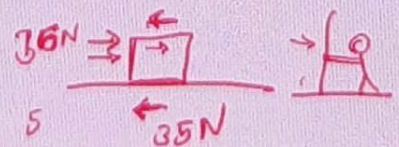
- Which type of props shall be used to reduce convergence or bed separation?

Ans – Early bearing props or hydraulic props

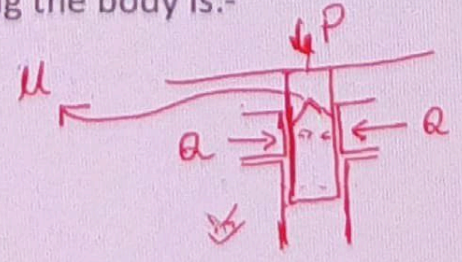
- Which type of yielding props accept the maximum load with minimum yield?

Ans – Early bearing props





- If two bodies are held in contact and one moves with respect to the other the force P for just moving the body is:-
- $P = \mu \times Q$
- Where,
  - μ is the coefficient of friction
  - Q is the normal force



- If two friction clamps are held in the upper then:-
- $P = 2\mu \times Q$
- P can be increased by increasing μ or Q or both

MINING GYAN

Yielding Props

By – Devendra Singh Tomar

MAMC Friction Props

- It consists of two steel tubes of which the inner member is attached to the outer member by a spring locking pin which prevents the inner member to come out completely from the outer member beyond the extended length.
- The clamp unit which is fixed at the top of the outer member provides the necessary friction grip by hammering two locking wedges alternately.
- In the closed position of the props adequate finger clearance has been given to avoid the injury to miner's hand during operation.
- The important features of these props are as follows:-
  - These are early bearing props and accept the roof and load very quickly.
  - They have constant load yield characteristics.
  - The weights of these props compared to their nominal load are less in comparison with other types.

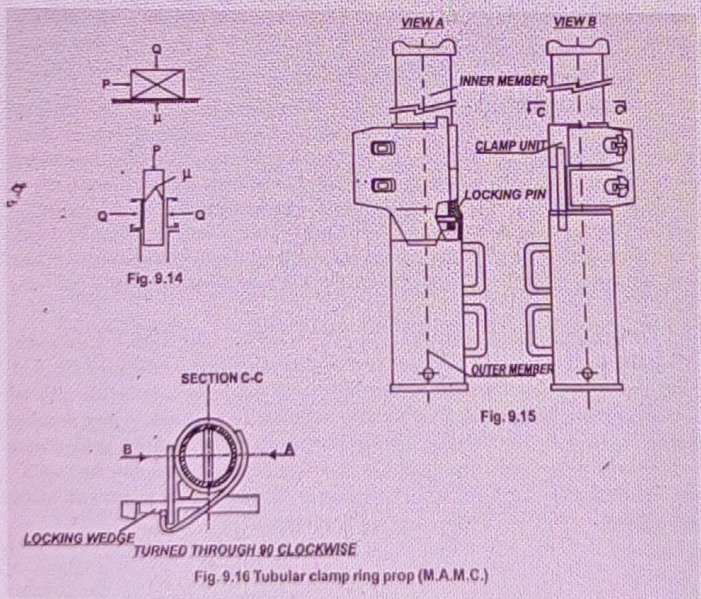


Fig. 9.14

Fig. 9.15

Fig. 9.16 Tubular clamp ring prop (M.A.M.C.)

Questions

- What is used in the friction prop to prevent the inner tube from coming out of the outer tube completely?

Or

- Which thing is used in a friction prop to attach the outer and inner tube with each other?

Ans – Spring lock pin

- What is used in a friction prop to provide the friction grip to the inner tube?

Ans – Clamp or locking wedges

- Friction prop is a type of _____

Ans – Early bearing prop

Hydraulic props

Hydraulic props

- A hydraulic prop is simply a hydraulic jack.
- These props have been used at longwall mechanised faces in our country.
- A hydraulic prop can immediately take two third of the maximum load, but when overloaded it will take the designed load after which the resistance is uniform and about 3/4th of the maximum load is taken.
- A hydraulic prop basically consist of two oil-filled cylinders, the upper one telescoping into the lower one.
- A piston head is fitted to the lower end of the top member and this provides a seal with the inside wall of outer cylinder.
- The piston (and the top members to which it is fitted) does to slide down, unless the load on it exceeds certain limits.
- The resistance to downward movement of the upper member is provided by the pressure of the oil in the cylinders and this oil pressure builds up by the operation of a pump at the time of setting up the prop in piston.
- There are two ways of building up the oil pressure in the prop by a pump.

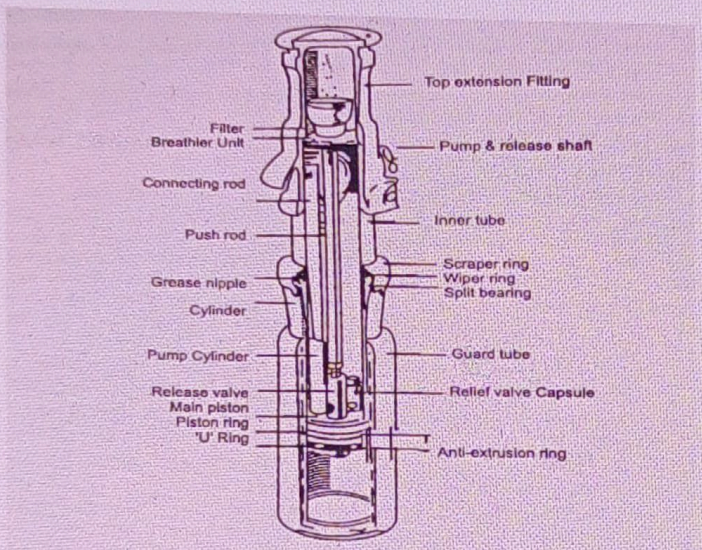


Fig. 9.17 MAMC-Dowty hydraulic prop

Oil Pressure Circuit System

- **Closed Circuit System**
  - In the closed circuit system a built-in pump is provided in the prop itself and forms an integral part of it.
  - The pump is operated by a external detachable handle.
- **Open Circuit System**
  - In the open circuit system an external pump, serving a number of props from one central site.
  - It is connected to the prop by high pressure hose pipes and operation of the pump builds up the pressure of oil contained in the cylinders of the prop.
  - Non-return valves provided on the prop retain the oil pressure.

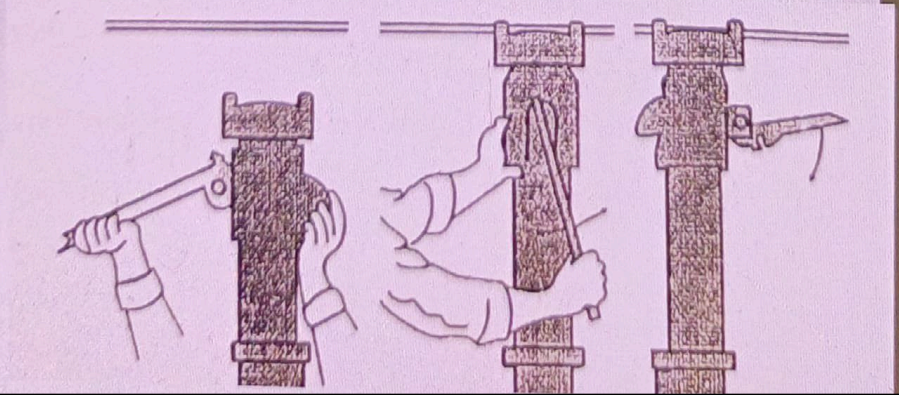
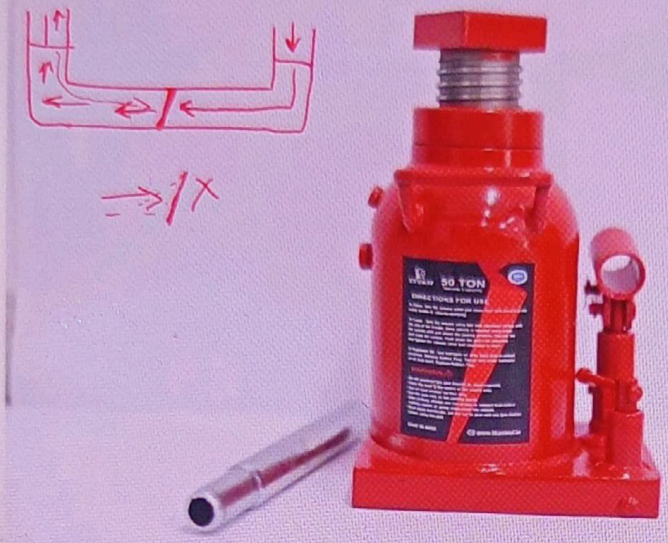


Fig. 9.18 Hydrulic prop., with built-in pump.
Left-extending the prop, Middle-setting the prop., Right-withdrawl of prop.



MAMC Hydraulic Prop

- It consist essentially of
  - inner tube
  - a pump cylinder with oil
  - a guard tube
  - a release valve
  - a non-return valve
  - a main piston
  - a top extension fitting
  - a pump
- The inner tube and pressure cylinder can be extended like a ram by hydraulic pressure.
- The pump can be operated by an outside key or handle.
- A large diameter steel tube connects the lower reservoir with a relief valve capsule.
- Action of the handle pumps the oil from the inner tube to the outer tube, thus extending the inner tube.
- After the prop has been so extended up to the roof, further operation of the pump handle provides the initial bearing pressure (or initial setting load) which is 5-8 tonnes.

- The pumps handle is then withdrawn.
- In course of time when the roof pressure on the prop gradually increases the inner tube will not slide down till the load is 40 te, (in the case of 40-te prop) as the hydraulic fluid is compressed till that load is reached.
- When the load on the prop exceeds 40 te, a relief valve operates.
- During the yield, the oil pressure may be from 200 to 500 kgf/ cm^2.
- The prop can be withdrawn easily by pulling the release shackle
- Withdrawal can be effected from a distance by attaching a chain to the relief valve shackle and pulling it.
- A hydraulic prop can be tightened in a few seconds to any length within a wide range.
- The hydraulic oil used may be water with 10% suitable oil.
- The oil is DTE light oil, servo system 311 supplied by Indian Oil Corporation.
- It has anticorrosive characteristics.

Questions

- On which principle hydraulic prop works?

Ans – Pascals principle

- Relief valve is related to _____.

Ans – Hydraulic prop

- What is the initial setting load provided to the hydraulic prop?

Questions

- On which principle hydraulic prop works?

Ans – Pascals principle

- Relief valve is related to _____.

Ans – Hydraulic prop

- What is the initial setting load provided to the hydraulic prop?

Ans – 5 to 8 tonnes

- Which device operates in hydraulic prop when the load on it is more than its limit?

Ans – Relief valve

- In hydraulic prop what is the mixture of hydraulic oil?

Ans – Water with 10% oil

- Which oil is used in hydraulic prop?

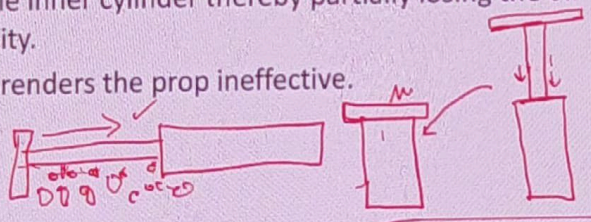
Ans – DTE Light oil, Servo System 311 by Indian Oil Corporation

- What is the characteristics of oil used in hydraulic props?

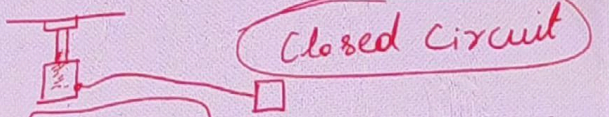
Ans – Anticorrosive characteristics

MAMC 40te props of its own design

- A precaution which must be borne in mind in connection with hydraulic props is that they must not be left lying on the floor, and the prop must be withdrawn before full closure.
- On longwall faces having sand stowing, hydraulic props which were not used carefully, developed scratches due to sand rubbing on the inner cylinder thereby partially losing the oil-sealing capacity.
- Such neglect renders the prop ineffective.



Salzgitter



- This is a hydraulic prop of open circuit type, normally used with sliding roof bars.
- The Salzgitter/MAMC hydraulic prop can be extended, according to prop type, by mounting of extension pieces.
- Setting of Salzgitter/MAMC hydraulic props is effected by hydraulic pressure, which, produced by a central high-pressure pump, is delivered to the setting gun via a lead in the supporting system.
- The setting gun is put on the filling valve of the prop
- The pressure medium flows under the piston, pushes out the inner ram tube and sets the prop safely with the setting load pre-set by the hydraulic pressure between cap and bottom.
- The hydraulic oil used is a 5% oil emulsion, and 95% water; pH value 5-8 pH.
- The prop can take the roof load until the nominal load adjusted in the operating valve has been reached.

- As soon as the nominal load has been reached, the operating valve opens and some pressurised fluid spurts out until a pressure spring closes the operating valve again.
- This operation occurs whenever the nominal load has been reached. Thus the prop is always protected from over-load of rock pressure.
- Due to the extension feasibilities to prop type, the prop lengths can be easily adapted to seam heights underground
- When the prop is to be withdrawn at the goaf edge, the releasing valve can be actuated by means of a releasing key which is extended by means of a rope or chain from the miner's

- Due to the extension feasibilities to prop type, the prop lengths can be easily adapted to seam heights underground
- When the prop is to be withdrawn at the goaf edge, the releasing valve can be actuated by means of a releasing key which is extended by means of a rope or chain from the miner's safe position effecting the flow-off of the pressure fluid out of the cylinder space.
- After this the prop is ready again for another setting process.

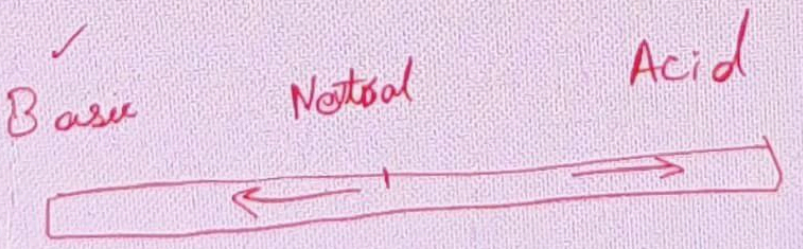
Questions

- Setting Gun is related to _____

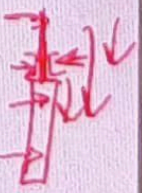
Ans – Salzgitter Hydraulic prop

- What is the mixture of hydraulic oil in salzgitter hydraulic prop?

Ans – Water with 5% oil



Comparison Between Friction & Hydraulic Props



- A hydraulic prop is superior to any friction prop in so far as acceptance of a sufficiently high and uniform load in the underground application is concerned.
- The friction prop has irregular behaviour under load and it slides more than a hydraulic prop under a similar load.
- A high setting load is obtained in a hydraulic prop.
- Friction prop is lighter in weight and has a superior extensibility.
- Friction props serve a long life of sand stowing faces.
- Friction as well as hydraulic props can be easily withdrawn.
- Wooden lids are not used with friction props and hydraulic props. Where such props have accommodated steel roof bars, the prop heads have prongs which prevent the prop from being joilted or forced out of position by an accidental heavy blow or roof pressure.

CMRS Designed hydraulic Prop.

→ Features of this prop

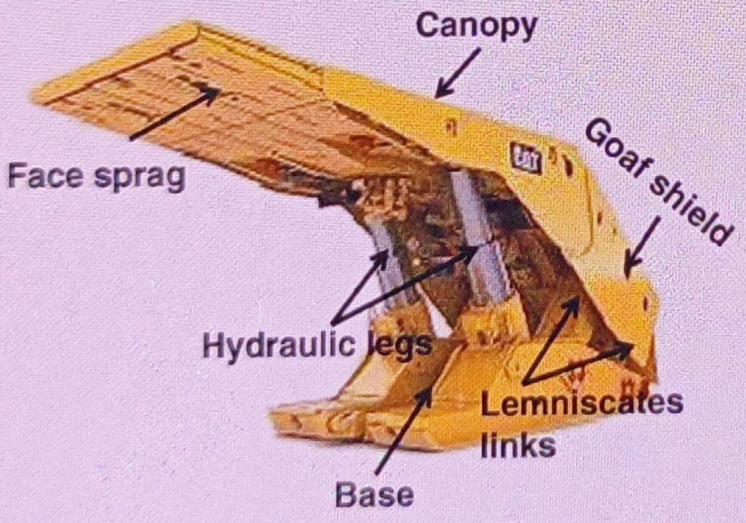
① If any part of prop gets damaged U/g, it can be repaired without taking it to the surface.

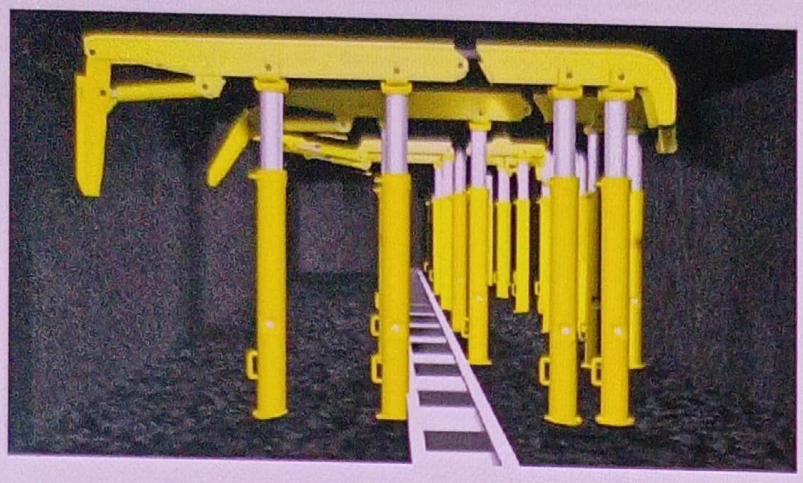
② Load indicating system also acts as a safety release capsule.

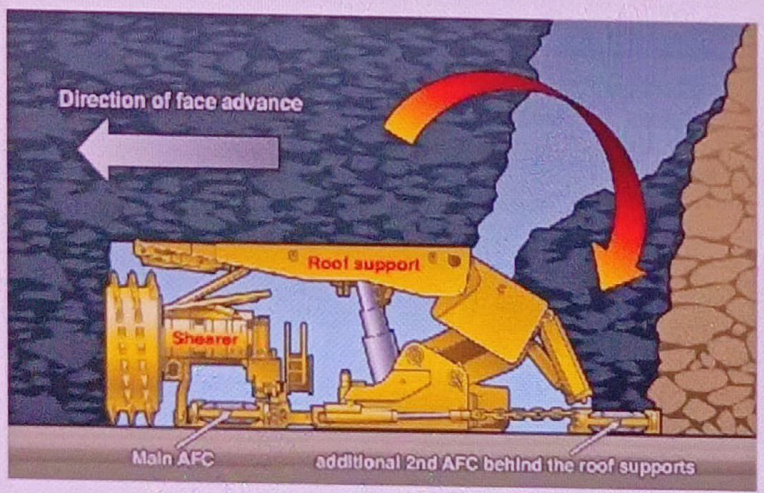
→ Prop density → No. of props required to support roof area of $1\ m^2$

Bars.

→ Cantilever bars are used.
→ It is stronger and gives more resistance to bending.
→ It has a free end and a fixed end.
→ Free end में sliding bar होता है जो की roof के हिसाब से adjust करता है।
→ Cut करते time sliding bar 3 props के ऊपर rest करता है और जैसे ही Coal load होता है bar को move करके set करते हैं।







Self Advancing or Walking Supports

→ These are open circuit type hydraulic chocks.
→ New site पर set करने के लिए hydraulic shifting cylinders से push करते हैं।
and hydraulic pressure से set करते हैं।
→ hydraulic pressure centrally located pump से provide किया जाता है।
... is not required to handle the support

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→ New site पर set करने के लिए hydraulic shifting cylinders से push करते हैं। and hydraulic pressure से set करते हैं।

→ hydraulic pressure centrally located pump से provide किया जाता है।

→ Workman is not required to handle the support

→ First time in India → Monidih Colliery.

→ hydraulic props common canopy and floor base से connected होते हैं।

→ Props के एक set को down करके (legs) support को move करते हैं।

→ एक बार में 0.6m move करता है and the set against the roof.

→ face conveyor को double acting ram move करते हैं।

4 leg & 6 leg Canopy Supports.

→ 6 leg → 240te support → 1450mm, 2360mm for seam thickness

→ 4 leg → it is heavy → 310 te, 590 te, 728 te

→ Dist. b/w 2 units → 70 to 150 mm.

→ Single lever की help से पूरा operation होता है

→ Dead Mans Handle.

Questions

- Dead mans handle is related with _____

Ans – Powered support

- Which type of bars are used in powered support?

Ans - Cantilever Bars

- Which of the following are heavy type of powered support?

Ans – 4 leg powered support

- No. of props required to support $1m^2$ roof area is known as _____

Ans – Prop density

- In powered support which type of circuit system is provided?

Ans – Open circuit system

- When the pump is centrally located to give hydraulic pressure then it is known as _____ circuit system

Ans - Open circuit system

MINING GYAN

Roof Bolting

By – Devendra Singh Tomar

Roof bolting

- The term roof bolting is applied to the practice of drilling vertical holes in the roof and fixing steel bolts into them in such a manner that the bolts grip the strata and support the immediate roof.
- The bolted roof strata behave as one thick beam capable of supporting not only their own weight but the weight of the strata.

Slot And Wedge Bolts

- It consists of:-
  - Mild steel rod
  - 25 mm dia.
  - Nearly 1.3 m long
  - Split at one end for nearly 160 mm
  - Threaded at the other end for about 125 mm.
- Into the slot is fitted a wedge 150 mm long. To install the bolt in position a vertical hole, nearly 125 mm less than the length of the bolt, is drilled and the bolt, having the wedge fitted at the split end, is inserted into the hole and hammered in position. The split end having the wedge somewhat widens in the hole and grips the rocks.
- A bearing plate of mild steel, 150 mm x 150mm is placed on the bolt and a nut is tightened.

- The better the grip, the sounder is the installation.
- This type of bolt is popular as it can be easily made in the colliery workshop, is cheap in the first cost and can be installed in holes drilled by the usual coal drill.
- It cannot be recovered.

19:27

Expansion shell type bolt

- One of the expansion shell bolts works as follows:-
  - A forged head or stud type bolt complete with expansion shell and plug of Nanda Manufacturing Company.
- Completementary taper of plug and shell provides full contact with the wall of hole.
- Its installation is as follows:-
  - Drill hole of recommended diameter at right angles to bearing surface, to a depth larger than the bolt to be used.
  - Place washer on bolt thread.
  - Plug on bolt four to eight turns.
  - Insert in hole until washer and bolt heads are against mouth of hole.
  - Apply torque as per recommendation.
  - This expands the serrated sheet against the wall of hole.

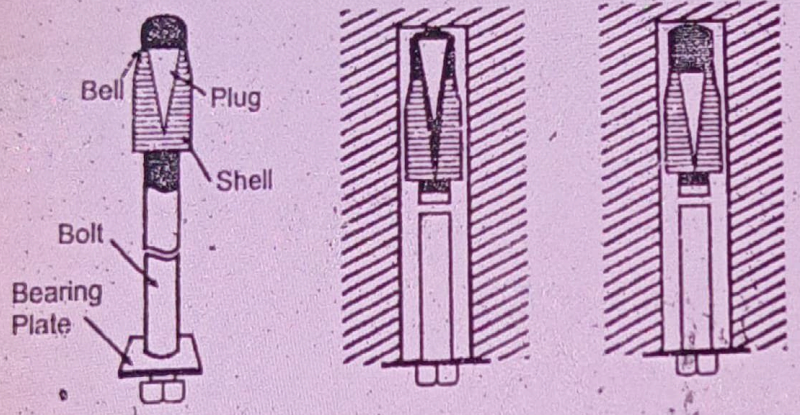
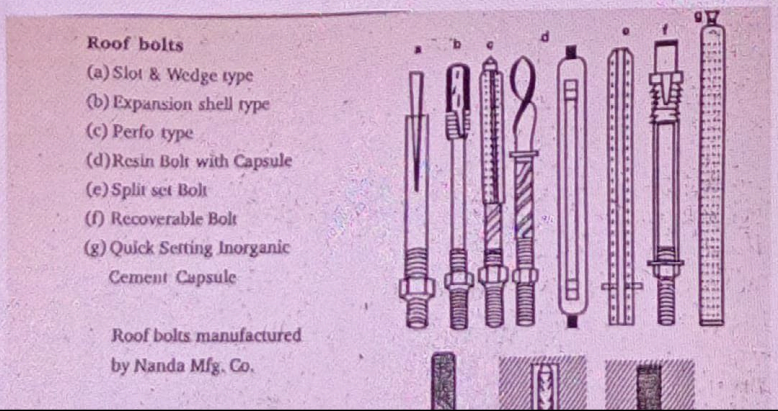


Fig. 9.28 Dexpansion shell bolt

Perfo bolts

- A ribbed/tor steel rod is threaded at one end and chamfered at the other end for easy insertion.
- Sleeve of recommended diameter made of flexible galvanized wire mesh (size 5 mm x 1 mm dia.) is used to insert the sand cement mortar into the drill hole.
- Two semi-cylinders are manufactured from 0.63 mm thick perforated steel sheet; alternatively wire mesh cylinder is manufactured from 5 mm mesh x 1 mm dia.
- They are usually 3 to 4 mm less than bore hole dia. It is advisable to use perforated semi cylinder tubes for lengths longer than 1500 mm.
- For installation of a perfo bolt, drill hole longer than bolt to be used.
- Take wire sleeve and fill it with mortar (cement, sand and water 1:1:0.6 by vol.) For the remaining procedure



Roof bolts

(a) Slot & Wedge type
(b) Expansion shell type
(c) Perfo type
(d) Resin Bolt with Capsule
(e) Split set Bolt
(f) Recoverable Bolt
(g) Quick Setting Inorganic Cement Capsule

Roof bolts manufactured by Nanda Mfg. Co.

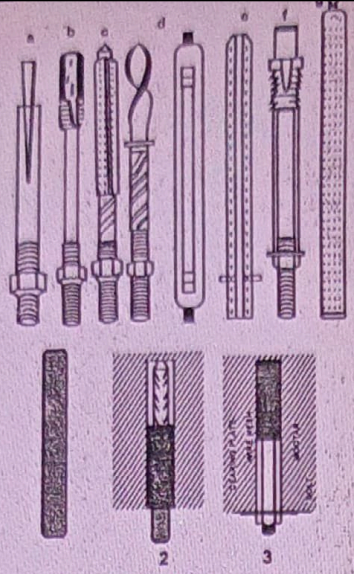
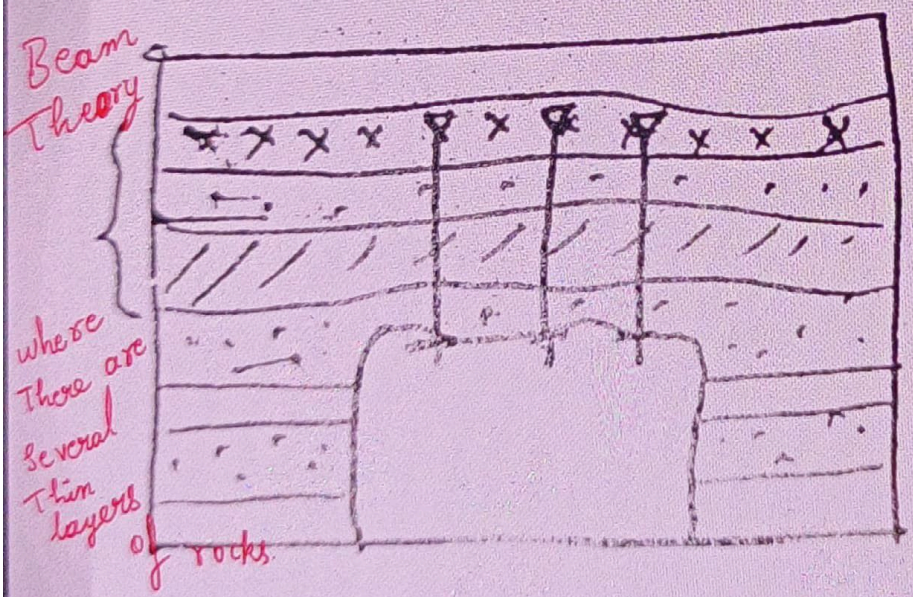
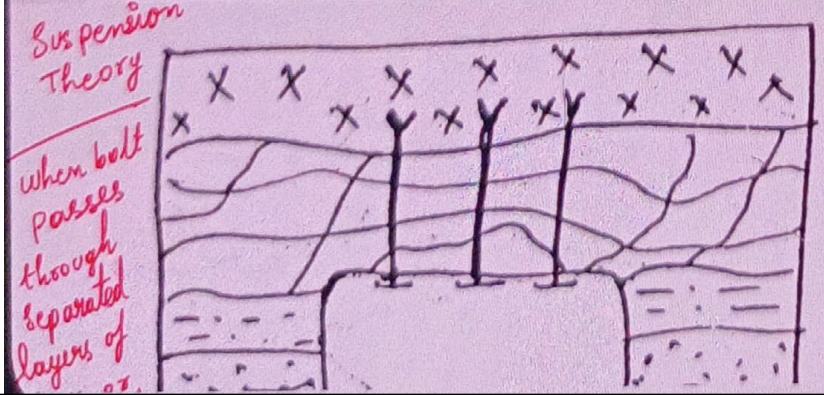


Fig. 9.29 Perfo bolt

Principles of roof Bolting

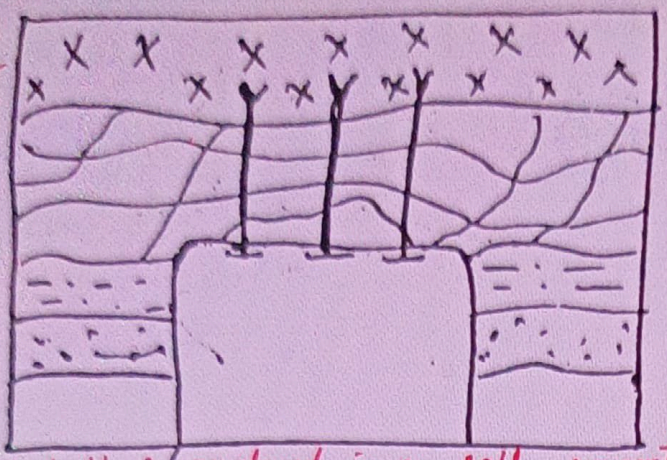
- There are three theories put forward to explain the action of roof bolt.
  - Beam theory
  - Keystone theory
  - Suspension theory
- The beam theory is widely accepted. According to this theory, the roof bolt assists in joining together the rock beds through which the bolt passes. The joined beds form a sort of thick beam which supports the weight of the strata above.
- For deficient roof support bolts in sufficient number should be fixed immediately after the roof is exposed, i.e. immediately after loading of coal in an advancing heading is over.
- Roof bolts are not very successful in watery holes as the grip of bolts is reduced.
- During roof bolting instead of a plate, a girder or a bar may be used to support the roof.
- The girder or bar provides supports to a crack or slip in the roof.





Suspension Theory

When bolt passes through separated layers of rock or pieces of rocks

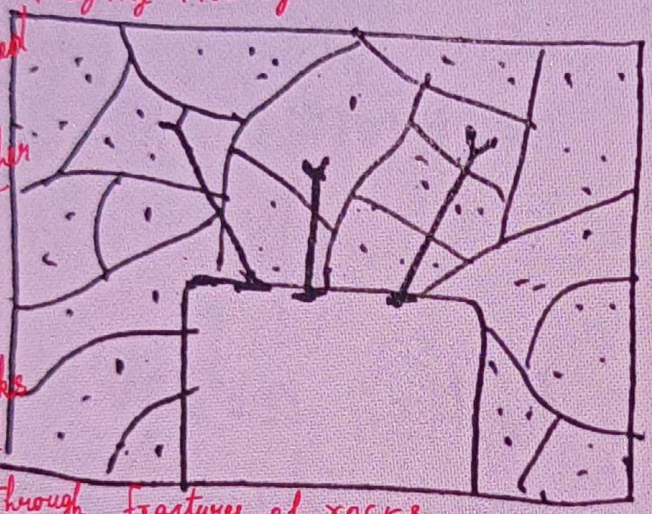


& bolt is anchored in a self supporting layer above separation

Key stone or Keying Theory

When fractured rock is bolted together

The bolt passes through angular blocks of rock and also through fractures of rocks.



Advantages of roof bolting

- It is simple to apply, easy to mechanise and moderately cheap in cost; manpower required for fixing supports is less than with conventional supports.
- It gives greater headroom and clearance in the roadway. This facilitates easy manoeuvring of the machines.
- The hazards due to accidental dislodgement of conventional supports caused by derailed tubs, blasting, etc. are reduced if systematically carried out.
- It results in greater safety and less accidents due to roof falls.
- The supports are fireproof.
- Handling and transport of heavy support materials involved in conventional support sare eliminated;
- Storage space required is small;
- The protrudings ends of bolts can be used to suspend water or air pipes and cables;
- Stability of the support does not depend upon the condition of the floor and this is a considerable advantage where floor is soft;
- Where excavations are wide roof bolting is useful
- Bolts can be used to secure sides in headings and sinking pits.

Disadvantages of roof bolting

- It cannot be applied in all cases;
- It gives no warning of impending failure;
- Some types of bolts are not recoverable e.g. slot and wedge type.

Application of Floor bolting

- In many roadway supported by conventional methods, having of the floor is of such magnitude that the roadway is completely disrupted.
- The erection of conventional supports may promote such floor having in some cases because the roof weight is transmitted to the floor through the props or archés and these then pierce the floor, breaking it up and setting it free to move.
- Floor bolting, like roof bolting, has as its object the formation of a strong compound beam of clamped floor beds which will be strong enough to resist the lifting forces acting upon it.
- In some cases, it is found sufficient to concentrate the holes near the middle of the roadway where maximum movement is liable to occur.
- But the best pattern of floor bolting to prevent heaving of floor can be found by experiments.

MINING GYAN

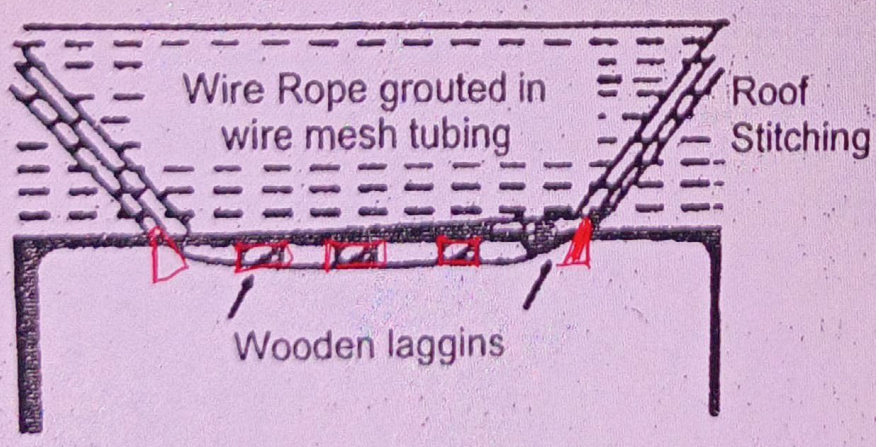
Other roof supports

By – Devendra Singh Tomar

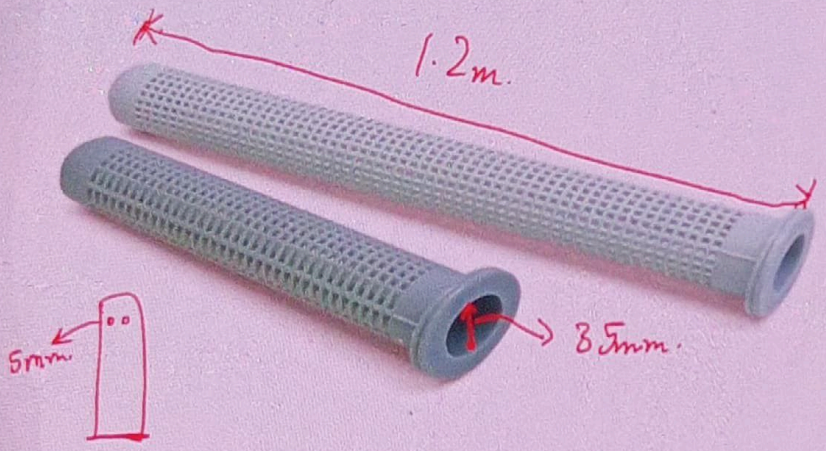
Roof stitching

- In a gallery two slanting holes are drilled by the usual coal drill in the roof.
- The holes are about ***1.4 m to 1.5 m deep.***
- To fit the hole a wire gauze (10 mesh) is made in the form of a tube open at one end.
- In this tube of wire gauze viscous cement mortar is filled up to ***three fourth length.***
- The wire gauze is then inserted into the hole in the roof.
- ***Old wire rope 18 mm to 22 mm diameter*** is cut into suitable length to cover the depth of the two holes and the distance between them.
- Each end of the wire rope is prevented from untwisting by tying it with binding wire.
- The wire rope is then inserted into the cement mortar of the wire gauze tube held in the holes.
- As this is done, some of the cement mortar in the wire gauze is squeezed out of the container and it fills up the hole.

- The wire rope is held in position by hammering a wedge at the mouth of the hole.
- The assembly is allowed to set for 24hours and thereafter the cement mortar becomes sufficiently hard so that the wire rope does not come out of the hole even when the sagging middle portion is pulled by hand.
- The pairs of holes for roof stitching are drilled at 1 to 1.3 m intervals and the roof stitching serves as a substitute for the conventional support by the set of timber props and bar.
- Wooden laggings are placed between the roof and the sagging portion of the wire rope.
- Where the roof is bad sometimes an extra holes (vertical) are drilled into the middle of the gallery and a wire rope inserted into it in the same manner as in the inclined holes.
- The principle of roof stitching is the same as that for roof bolting, viz. the immediate rocks are held together as a composite stratum of large thickness



- This method of support was found to be not only effective but also the cheapest.
- At Ballarpur mines a fault zone, over 60 m length, was successfully supported with the ropes.
- To make the technique effective it is recommended that
  - The face should not advance more than 2.4m from the last tensioned rope.
  - Short ropes should be used in between long ropes for further reinforcement and to prevent bed separation
  - Ropes should be tensioned while using good wooden sleepers.
- Where the roof condition deteriorates immediately after blasting, roof stitching cannot be tried.
- Plastic perforated sleeves, 35 mm dia. 1.2 m long, with 5 mm dia. perforations have been tried instead of wire mesh and it provided anchorage strength of 10 tonne
- Preparation of the wire mesh sleeves at the mine takes time and the workers complain of the scratches on the hands due to handling of the wire mesh.



Questions

- Which type of holes are drilled for roof stitching if the roof is bad?

Ans - Vertical holes

- What should be the maximum distance between the face and last tensioned rope for effective roof stitching?

Ans – 2.4m

- Under which roof condition roof stitching should not be done?

Ans – when the immediate roof deteriorates immediately after blasting

- How many mesh wire gauze is used in roof stitching?

Ans – 10 mesh

- what is the dia of wire rope used in roof stitching?

Ans – 18mm – 22mm

- What is the length of wire rope used in roof stitching?

Ans – depth of two holes + distance between two holes

Resin Capsule

- Roof bolts of the wedge-and-split type an expansion shell type are not suitable in soft rocks due to their poor anchorage in the latter.
- The wire mesh grouted bolts or roof stitching, though suitable for soft rocks, require about 24 hours for the cement mortar to set.
- The use of styrene resins instead of cement grout reduces the interval between the moment the bolt is installed and the moment it is ready to carry a load.
- After a lapse of 15 minutes the bolt can support a 5-te load, and 20 minutes thereafter, a 10 te load.
- The resin capsule is a ***polythene cartridge***, 28 to 35 mm dia. and 330 mm long.
- The components of a resin capsule are ***resin, a hardener and a filler***

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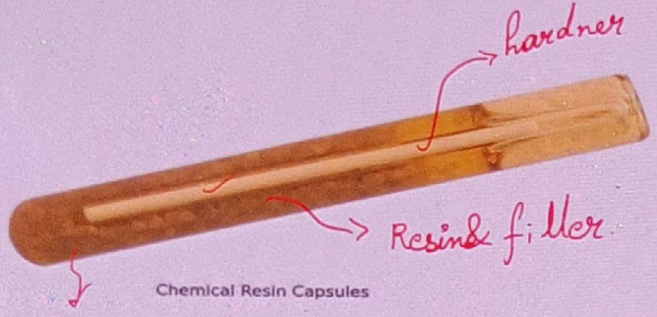
10 te load.

- The resin capsule is a ***polythene cartridge***, 28 to 35 mm dia. and 330 mm long.
- The components of a resin capsule are ***resin, a hardener and a filler.***
- The resin is a synthetic polyster resin which has the consistency of a jelly at normal temperatures.
- The filler is coarse sand or small sized dolomite chips.
- The hardner is kept in a separately scaled glass tube which is placed at the centre of the polythene cartridge of resin and filler.
- The composition of the resin and the hardner are trade secrets.
- If the glass tube is broken and the hardener allowed to come in contact with the resin and the two are mixed well, the mixture hardens within 30-40 seconds and becomes solid.



Chemical Resin Capsules

Resin Capsule in Polyethe Cartridge

- In actual application vertical or inclined holes are drilled in the soft rock of roof with the usual coal drill fitted with a slightly larger dia. drill rod for 40 mm dia. hole.
- The roof bolt to be used is 22 mm dia. m.s. rod, with a length of 230 mm at one end in the form of a scroll (like an auger).
- The other end of the bolt is threaded to receive a nut.
- A thin circular washer of 40 mm dia, is provided at 250 mm below the bolt head to prevent falling of resin while mixing inside the hole.
- The roof bolt is then attached to the coal drill through an adaptor.
- The resin capsule and the bolt are inserted in the hole, the capsule leading.
- The bolt is pushed as far as it can go and then the drill switched on.
- As the bolt starts revolving it is pushed inside the capsule.
- The rotation of the scrolled end tears open the polythene wrapper and breaks the thin-walled glass tube of the hardener.
- The bolt is rotated only for 15 seconds.

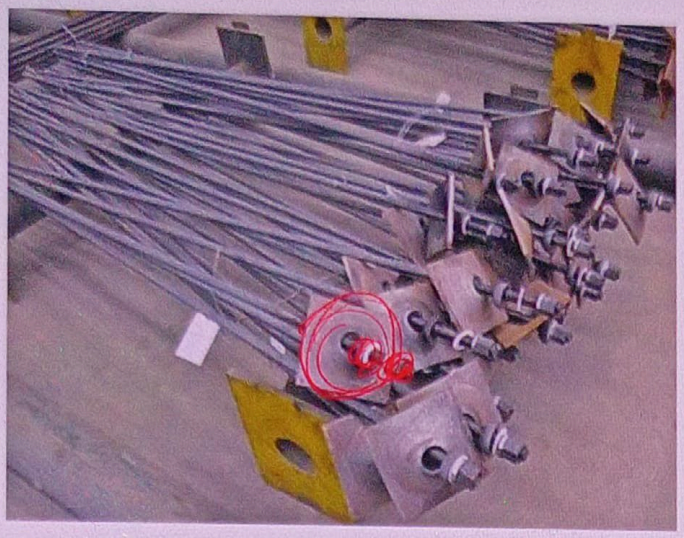
- The hardener and the resin, coming in intimate contact with each other, result in a solid compound within 30-40 seconds with the scrolled end firmly embedded in it.
- The solid compound that is formed grips the side of the hole

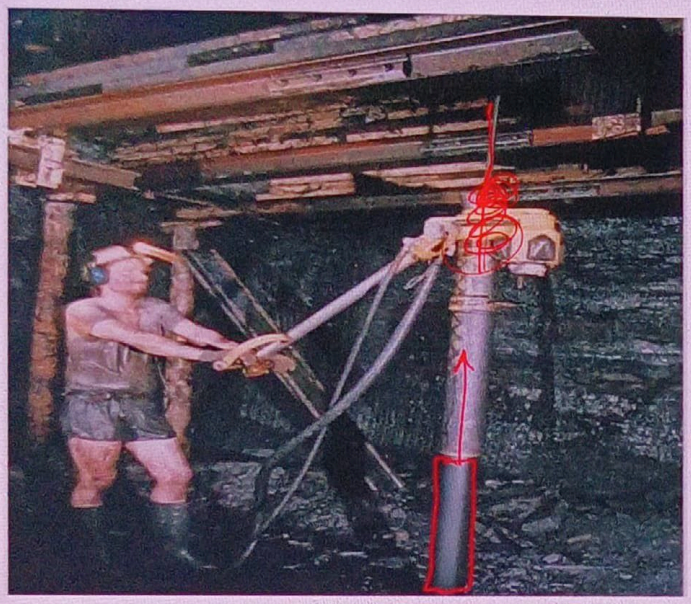
- The hardener and the resin, coming in intimate contact with each other, result in a solid compound within 30-40 seconds with the scrolled end firmly embedded in it.
- The solid compound that is formed grips the side of the hole.
- The solidifying process inside the hole is indicated by the gradually diminishing speed of the drill.
- The roof bolt is thus anchored in the hole.
- A bearing plate and a nut are then fixed to the threaded end outside the hole.
- The anchorage strength is 8-9 te even with bondage for a length of only 300 mm.
- Wooden dowels 36 mm dia. made of hard wood, capable of taking more than 10 te tensile load, could also be used as bolt material.
- Capsule: It contains separated pre-measured quantity of filled polyestered and resin - catalyst.
- Outer skin of capsule is made of nylon or special paper.
- Filler is crushed rock- silica, barytes, soap-stone, etc. usually of 250 mesh.

- Catalyst tube is usually made of glass tube with cork on both sides to prevent mixing of catalyst with resin unless desired.
- For a capsule the ***gel time*** is the time between the start of the running operation and the onset of the solidification process.
- This time varies from 2 to 5 minutes, depending upon the type of bolt used.
- The curve time follows immediately after the gel time and is the time for resin to harden completely and become load bearing.
- The bolt should not be loaded for the first half an hour.
- Under normal conditions the capsule can be stored for 3 months from the date of manufacture.
- Cured resin has properties as follows:-
  - Compressive strength 125 MN/m² (12.5 kg/mm³)
  - Tensile strength - 50 MN/m² (5 kg/mm³)
- The capsule has a length of 310 mm but the diameters are suitable for two hole sizes, 40-43 mm and 31-33 mm. The sp. gr. is 1.9.

Gel time → start operation of rotating bolt → Resin Capsule hard होना start कर देता है।

Curve time → hard होना start करने से लेकर load लेने लायक Hard होने तक का समय।





Rotary Drill machine

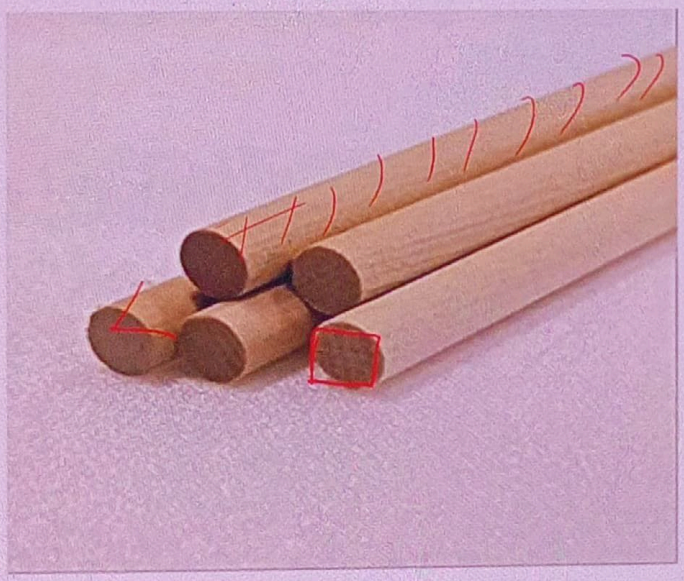
Procedure of using resin bolt

- For using the resin bolt the procedure is as follows:-
- Air blow or water flush the hole to remove the dust.
- Check that the bolt is free to rotate in the hole and that the hole is of correct depth, i.e. 75 mm less than bolt length.
- Insert the capsule into hole, push gently home with bolt.
- Drive bolt home, spinning it all the time with drill. Do not try to rush this stage.
- Spin bolt for further 30 seconds once it is home.
- Continue longer if an impact wrench is being used and bolt is rotating very slowly.

- Spin bolt for further 30 seconds once it is home.
- Continue longer if an impact wrench is being used and bolt is rotating very slowly.
- Removes drill and can nut disturbing bolt as little as possible until 5 minutes after 'gel' has occured.
- Gel time can be detected when the bolt becomes too stiff to rotate slightly between fingers.
- Fit plate washer and nut over bolt and tighten up.

Wooden downel

- It comprises wooden bolt bonded along its whole length with polyester resin.
- Immediate resistance to strata or coal movement is offered without the necessity of tensioning because the bolt is of wood and can easily be cut; cutting machine can operate freely.
- They are light, easy to use and positive results are quickly obtained with a minimum of equipment and supervision.
- Bolts are manufactured from specially selected timbers which are straight grained, knot and resin free.
- One end is chamfered to 23 deg. taper to allow easy perching of the capsules, and the other end is left square to permit the attachment to a suitable box section spinning adaptor fixed into the chuck of a drilling machine.
- The surface of the bolt is left roughened to give good adhesion between the resin and the bolt.



Bamboo Bolting

- CMRS has experimented with a system of roof bolting known as bamboo bolting, as a temporary roof support in places such as splits in depillaring districts.
- A bamboo slightly longer than the depth of the hole for roof bolt is split longitudinally along the full length.
- The two pieces are then tied together by a thin wire at 4-5 places after inserting a wooden wedge only partially at one end.
- Care is taken to see that the knots on the two pieces of the split bamboo are staggered.
- The wedged end is inserted into the hole and at the other end another wooden wedge is fitted.
- The bamboo, with wedges at either end, is then hammered into position in the hole.
- The hammering pushes apart the two splits of the bamboo and breaks the thin wire.
- The bamboo splits grip the hole sides and the gripping effect is enhanced by the knots of the bamboo.
- Sometimes a bearing plate is fitted on to the bamboo before inserting the wedge at the exposed end.
- The bamboo bolting is being tried only as a substitute for the conventional timber supports required for short periods in the splits and during extraction of stooks in depillaring.

Stowing Practice

By – Devendra Singh Tomar

Stowing

- It is also known as goaf stowing or goaf packing or stowing
- The materials used are
  - Sand
  - Earth
  - Boiler ash
  - Crushed material from OB
  - Shale from screening plants

Questions

- By which name stowing is also known as?
- Ans – goaf stowing or goaf packing
- Which of the following are the methods of stowing?
- Ans – handpacking, hydraulic stowing, pneumatic stowing, mechanical stowing
- In hydraulic stowing which thing is used for the transport of stowing material?
- Ans – water
- In pneumatic stowing which thing is used for the transport of stowing material?
- Ans – compressed air
- In mechanical stowing which thing is used for the transport of stowing material?
- Ans – belt conveyor

Methods of stowing

- Dumping with baskets
- Hydraulic stowing
- High speed conveyor belt i.e. mechanical stowing
- Pneumatic stowing – Material is transported with the help of compressed air

Advantages of stowing

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Advantages of stowing

- No chances of gas accumulation
- Leakage of ventilating air is eliminated
- Roadways and working places are safe
- Better roof control and surface subsidence is minimised
- High percentage of extraction
- Depillaring of contiguous seams in any order is possible
- No danger of inundation

Hand packing

- It is used where hydraulic stowing is not possible
- It is effective in flat and shallow seams
- Tubs can also be handled conveniently anywhere in flat seams
- It is also useful in seams steeper than 25°
- Efficiency – 10m^3 per man shift

Questions

- Which method of stowing is effective for flat and shallow depth seams?
- Ans – Handpacking
- How much sand is required for stowing per tonne of coal raised?
- Ans – 1.3 tonne
- Which method of stowing is not effective if the gradient of seams is less than 5 degree?
- Ans – hydraulic stowing
- What must be the maximum distance of river from mines for hydraulic stowing?
- Ans- 16km

Hydraulic stowing

- It is used in mines which are situated within 16km of rivers
- Roof and floor of seams are not affected by water
- Seams are not much deep, humidity is not a problem
- If depth of miens is more than 100m and seams are inclined, then it is successful.
- In shallow depth seams and flatter than 5° it is not successful

Steps involved in hydraulic stowing

- Gathering of sand
- Transport of sand to bunkers
- Transport sand hydraulically from bunkers
- Stowing of sand in the area

Sand required

- It is the sand required per tonne of coal extracted
  - One tonne of coal raised needs nearly 1.3te of sand
  - Where old workings exist, for 1te of coal extracted needs nearly 2.5te of sands
  - Bord and pillar workings – 1.8te
  - Longwall – 1.4te

Others equipments

- Bunkers - It is present at one side of shaft
- Mixing chamber
- Stowing Pipe Range – 1 in 3 to 1 in 4
- Water pipes – dia 125mm to 175mm
- Capacity of bunkers – 2 days
- Water tank – 1 day

Questions

- What must be the inclination of stowing pipe range?
- Ans – 1 in 3 to 1 in 4
- What must be the minimum capacity of bunker storage?
- Ans – 2 days
- What must be the minimum storage of water in water tank?
- Ans – 1 day
- In hydraulic stowing where we mix the water and sand?
- Ans – Mixing cone or mixing chamber

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- In hydraulic stowing where we mix the water and sand?
- Ans – Mixing cone or mixing chamber
- What must be the minimum distance between chute and mixing cone?
- Ans – at least 600mm
- If the distance between chute and cone is less than 600mm then what will be its effects?
- Ans – heap of sand

Mixing chamber

- The place where mixing cone is located is called mixing chamber
- Size of mixing chamber – sufficient to accommodate desired number of mixing cones and pipe ranges
- On the mixing cone screen is fitted to prevent stones larger than 25mm in size
- All fittings and cables should be moisture proof
- Distance between bunker chute an mixing cone must be at least 600mm to avoid heap of sand
- Water is mixed in the mixing cone by circular perforated pipe i.e. garland pipe

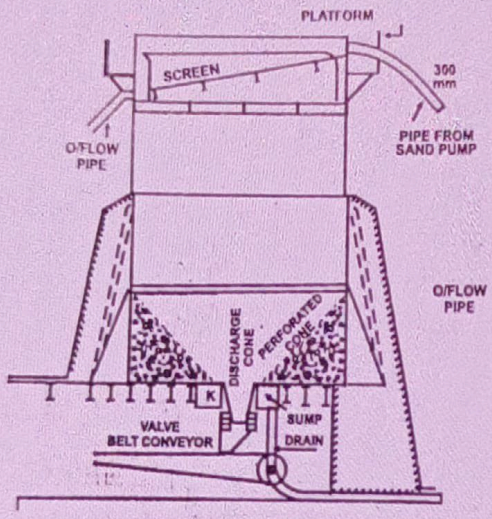

Fig. 10.3 Separator at Bhaladih

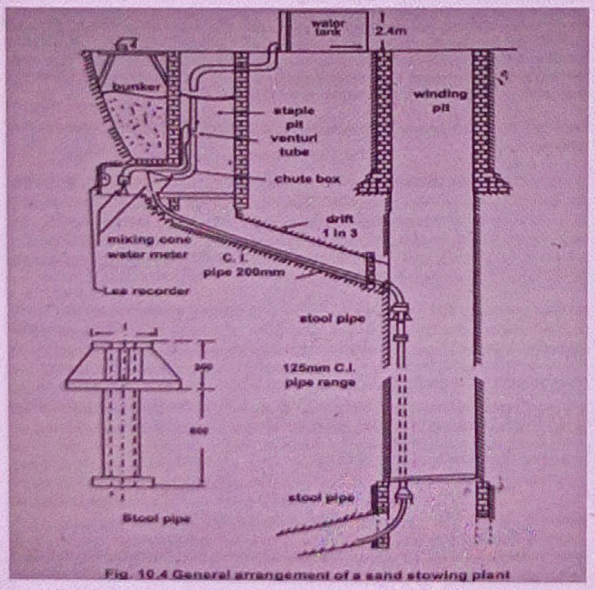

Fig. 10.4 General arrangement of a sand stowing plant

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- Devices to measure input of sand and water in mixing cone
  - Water meter – for water input also known as kent velocity meter
  - Lea recorder – for measuring sand input
  - V – notch
  - Venturimeter
- Type of pipes
  - CI pipes
  - MS pipes
  - Alkathene Pipes

CI Pipes

- Low tensile strength – 15kg/mm²
- Used only in drifts, shafts or main cross cuts
- Cannot be used at the face
- Dia – 125mm
- Length – 3m
- Thickness – 20 – 25mm thick walls
- Life
  - 20mm thick – 4 lakh te of sand
  - 25mm thick – 8 lakh te of sand

MS Pipes

- Lighter than CI pipes
- Tensile strength – 45kg/mm²
- Can be used as face pipe range
- Length – 5.5m to 6m
- Thickness – 12mm
- Life – 6 lakh te of sand

Questions

- Which instrument is used to measure the quantity of sand input in stowing?
- Ans – Lea recorder
- What is the use of kent velocity meter?
- Ans – to measure the quantity of water
- What is the life of 20mm thick CI pipes in stowing?
- Ans – 4 lakh tonne of sand
- What is the life of 25mm thick CI pipes in stowing?
- Ans – 8 lakh tonne of sand
- What is the life of 12mm thick MS pipes in stowing?
- Ans – 6 lakh tonne of sand

Alkathene pipes

- Much lighter than MS pipes
- Greatly resist wear by sand

Stowing pipe range

- Shaft range, drift range or borehole range
- UG roadways range
- Face pipe range
- Main intake shafts and roadways are avoided as water leakage causes humidity
- Main haulage roads are also avoided because
  - Leakage may wash away tram line packing
  - Clearing up of pipes jams because of large quantity of sand
  - Dangers to pipes due to derailment of tubs

Bendings

- Standard bends - 90˚, 45˚, 15˚
- Smaller deviations - 5˚ to 10˚
- Instead of one large bend 2 or 3 small bends are preffered

Pipe joints

- Fibre or asbestos washers between flanges
- Joints without coal tar rot after sometime and start leaking
- Joints are tested to a pressure of 15kg to 20kg per cm^2 of hydrostatic head
- Support of pipes
  - Supported by stool pipes placed at every 30 to 40m apart

- Support of pipes
  - Supported by stool pipes placed at every 30 to 40m apart
  - In the shaft range by buntons set 8 to 10m apart

Wear in pipes

- Shaft range – 2 lakh to 4 lakh te of sand (CI pipes 25mm)
- Lower portions – 8 lakh tonne
- Safe wall thickness in CI pipes in shaft range – 6mm with FOS of 3.5 for a depth of 400m
- Maximum wear in pipes – bottom portion covering an arc of 90°
- Rotation of pipes must be done in 4 stages
- At a time 10 to 15 pipes must be rotated

Hydraulic profile and H:L Ratio

- Incorrect hydraulic profile may cause cavitation
- Air will get trapped and will cause pulsation in the system
- Water can't be pressured to use at full available because high velocity will cause wear
- Length(L) of pipe range depends on height between mixing chamber and point of discharge(H)
- H:L ratio determines the efficiency of stowing
- 1:7 ratio is a good stowing rate

UG stowing arrangement & operations

- Before packing a goaf boxing is made near the face
- In longwall face distance between two boxing is 4 to 5m
- Stronger boxing for narrow packs i.e. 1.5m to 1.8m
- Less stronger boxing for wider packs i.e. 3.5m to 4.5m
- Types of boxing
  - Bamboo mating
  - Hessian cloth
- Coir Matting can be used 3 to 4 times i.e. why it has an economic advantage over bamboo mating and hessian cloth

- Bamboo or hessian cloth are nailed into the prop
- Props are at an inclination of 10°
- The top end leaning towards goaf
- Due to this inclination recovery of props or coir matting is easy
- Dip side boxing is made stronger with double bamboo matting and sometimes with wooden planks or coir matting
- Chocks are preferred instead of props in dip side packing

Questions

- What must be the maximum distance between stools used to support the pipe range?
- Ans – 30 to 40m
- What must be the maximum distance between buntons used to support he pipe of shaft range?
- Ans – 8 to 10m
- By what angle stowing pipe range must be rotated at regular intervals?
- Ans – 90 degree
- What must be the inclination of boxing towards goaf?
- Ans – 10 degree
- Which of the following materials boxing can be used 3 to 4 times
- Ans – coir matting

Stowing operation

- End of stowing pipe is kept 7.5m away from the dip side boxing
- Velocity of sand:water mixture – It depends on pressure head
- Coir matting
- Nozzle is attached at pipe end to increase throw distance
  - Without nozzle – 3m
  - With nozzle – 7m
- To stop stowing
  - Firstly flow of sand in mixing chamber is stopped
  - After 3-4 minutes flow of water is stopped. This helps to avoid pipe jams

Concentration of sand & water

- Depth – 200m to 300m – sand : water = 1:1.5
- Depth – more than 300m – sand : water = 1:1.3

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Rate of stowing

- It is the quantity of mixture flowing in pipe range
- Stowing pipe range has a limit of maximum quantity
- If it is more then, it will cause overflow to the mixing funnel (cone)
- If it is less then it will draw air in the pipe and will lead pulsatory flow due to this pipe jams
- Commonly flow rate for miens 200 to 300m deep
  - 80 – 100 te of stowing (sand) per hour
  - Nearly 1100 litres of water per tonne of sand

Pipe jams

- Pipes may burst due to the pipe jams because they create extra pressure on the pipe
- Overflow of water at the mixing cone or heaping of sand on the screen
- Clearing of pipe jam
  - Flushing clear water
  - Hammering at suspected places
  - Opening the pipe
- Prevention of pipe jams
  - Installing air removal devices
  - Correct hydraulic profile
  - Size of particle should not be more than 1/3 D i.e. D = pipe dia

Depillaring with stowing (Bord & pillar)

- Exposed roof area should not be more than $80m^2$
- Pillars are split into 2 to 4 stooks
- Split is normally 3m to 4.8m wide
- Width of rib 1m to 1.5m
- When 2nd split of the same stook is completed then the place is ready for stowing
- Not more than two such areas shall be left unstowed

Pneumatic Stowing

- Stowing material
  - Washery refuse
  - Boiler ashes
  - Surplus pit rubbish
  - Picking from the screening plant
  - Shale bands from the coal seam
- Sand alone is not used as it is heavy and abbrassive
- A mixture of sand and washery dirt may be suitable

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- Picking from the screening plant
  - Shale bands from the coal seam
- Sand alone is not used as it is heavy and abbrassive
- A mixture of sand and washery dirt may be suitable
- Debris containing much clay material is also unsuitable because it clogs the pipes.
- Damp material is less abrasive and gives tight packing in the goaf

- The crushed material passes from the crusher through 65mm to 75mm aperture wire screen to a storage bunker.
- Tubs are loaded at the storage bunker and lowered belowground
- Loaded tubs are taken to a tippler which tipples the material on the feeding hopper of the stowing machine which is situated at a convenient point near the goaf to be packed
- The compressed air is supplied to the face from the surface through pipes of 200mm to 300mm dia
- Capacity of compressor – 55 to 85 m^3 of free air / min
- HP – 400 to 600
- Compresses air to nearly 6kgf/cm^2
- The stowing pipes are of high carbon steel 10mm thick in lengths of 3m

Stowing machines

- Chamber machines
  - Torket single machine
  - Double chamber or automatic
  - Three chamber or vollautomat
- Compartment or pocket wheel machines
  - Beien
  - Brieden
  - Blast stower

Markham Blastower

- It consists of a rotating paddle wheel or drum driven at 40 to 50 r.p.m. by an electric motor of 15 to 20 H.P.
- The drum is divided into chambers which are filled with debris from the feed hopper above.
- As the drum rotates, each chamber in turn reaches a position where it forms a continuation of the compressed air inlet on one side and the delivery outlet on the other side.
- The compressed air thus flows through the chamber in the rotating drum, carrying the debris with it through the chamber in the rotating drum, carrying the debris with it through the stowing pipes to the face.
- The machine has a capacity of 1.5 m^3/ min with an air consumption of 70 to 85 m^3/min.
- Allowing for stoppages, stowing rate may average to 42 m^3/hour.
- Pressure gauges are provided to indicate air pressure at the inlet to the machine and the back pressure at the outlet due to resistance set up in the stowing pipes.
- The air pressure at the machine is regulated down to 1.8 to 2.8 kgf/cm^2

hopper above.

- As the drum rotates, each chamber in turn reaches a position where it forms a continuation of the compressed air inlet on one side and the delivery outlet on the other side.
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- At the discharge end of the stowing range a detachable deflecting nozzle is fitted to enable the operator to direct stowing material as required.
- The air velocity in the pipes is to about 60 m/sec.
- The average velocity of discharge of stowing material is about 15 m/sec.
- The packing in the goaf is nearly 70% as compact as the solid coal, Convergence of the order of 20% takes place in course of time.
- The compactness of the packing depends on the type of material, its size, density, moisture content, length of stowing pipe and the velocity of discharge.

Mechanical stowing

- In this system a high speed belt is used to propel the stowing material-into the goaf to be packed.
- The stowing material is transported to the thrower belt in the same manner as for pneumatic stowing.
- The material has to be deflected on the thrower belt by deflection plates known as scraper ploughs, which drops the material into a hopper above the high speed stowing belt.
- The thrower belt is mounted on a travelling carriage and a 660 mm wide belt is considered adequate.
- The driving drum rotates at 1000 r.p.m. giving the belt a velocity of 600 m/min (nearly 36 kmph).
- Driving motor is 25 to 40 H.P. and stowing of 50 to 60 te/hour of stowing material is possible.
- Good results are achieved if the stowing material is delivered to the thrower belt at a high speed and in the direction of belt travel.
- Barricade of wire netting is required is in other methods of stowing.

- It is the cheapest (less capital cost) and the number of manshifts required for roof control per 100 te coal produced is the least.
- Energy costs are a fraction of the costs for pneumatic stowing (consumption 0.3 to 0.4 kWh/m^3 material).
- Its disadvantage is that a prop-free front cannot be planned; the installation of a belt solely for throwing requires careful consideration from the stand-point of economy and roof control
- It is only applicable in thin flat seams or slices of 1.3 to 2.3 m thickness.
- The roof convergence is more compared to that in pneumatic stowing;
- Coal getting and stowing cannot take place at the same time;
- Installation of a conveyor in the tail gate for continuously feeding the machine is unavoidable.
- At the face, the operation creates a lot of noise and airborne dust and the risk of electrostatic sparks exists in this machine as the material is discharged at a high speed.

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MINING GYAN

Method of UG mining

By – Devendra Singh Tomar

Methods of coal winning

- There are two basic principles of winning coal in UG mines:-
- Bord and pillar also known as pillar and stall
- Longwall
  - Advancing
  - Retreating
- Following are the methods which work on the same principle system
  - Room and pillar
  - Horizon mining
  - Sub level mining
  - Level mining
  - Slicing

Selection of Bord and Pillar

- A seam thicker than 1.5m
- A seam free from stone or drift bands. Stone or drift bands, if present in a seam, can be easily disposed of for strip packing in longwall advancing method of mining
- Seam at moderate depth
- Seams which are not very gassy
- Seams with strong roof and floor which can stand for a long period after development stage is over
- Coal of adequate crushing strength

Advantages of bord and pillar

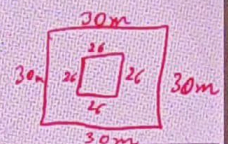
- Roads and airways are in solid coal and their maintenance cost is low throughout the life of the mine
- Coal output is obtained while roadways are being made during development stage, and naturally during the depillaring stage, thus providing a continuous flow of coal after the seam is touched
- Unlike in longwall mining no unproductive work of dining, strip packing is involved
- The development stage reveals the geological disturbances enabling the management to plan accordingly

packing is involved
- The development stage reveals the geological disturbances enabling the management to plan accordingly
- The working team is usually small at working faces
- Surface features are well supported

Disadvantages of bord & pillar

- Ventilation is sluggish as compared to longwall method at the working places
- The extraction losses are generally higher than in other methods of mining
- Work is carried on at a number of working places creating problems of supervision
- At great depths, the working by this method becomes difficult as effects of roof pressure are not easily controllable; heaving of floor and creeping of roof may result in loss of roadways
- The effects of subsidence and interaction on other seams are not even and not easily predictable or controllable

% of Extraction of coal



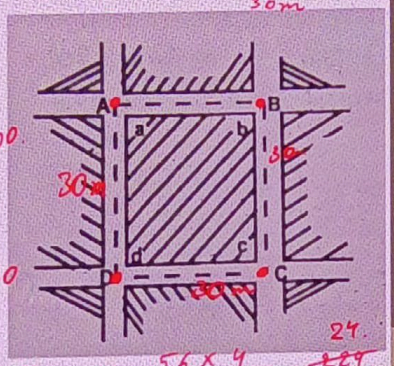
During development.
deep mines ⇒ 20%
shallow mines ⇒ 35%

% of extraction ⇒ $\frac{\text{Ar. of ABCD} - \text{Ar. of abcd}}{\text{Ar. of ABCD}} \times 100$

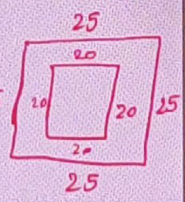
$= \frac{30 \times 30 - 26 \times 26}{30 \times 30} \times 100$

$= \frac{(30+26)(30-26)}{900} \times 100$ ⇒ $\frac{56 \times 4}{900} = \frac{224}{9}$

⇒ 24.89%



Q ⇒ Find the % of extraction



% of extraction ⇒ $\frac{25^2 - 20^2}{25^2} \times 100$

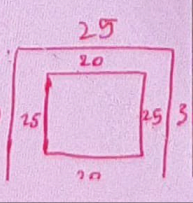
$= \frac{625 - 400}{625} \times 100$

$= \frac{225}{625} \times 100$

$= 36\%$

⇒ % of extraction ⇒ $\frac{25 \times 30 - 20 \times 25}{25 \times 30} \times 100$

⇒ $\frac{750 - 500}{\quad} \times 100$



$= \frac{625 - 400}{625} \times 100$

$= \frac{225}{625} \times 100$

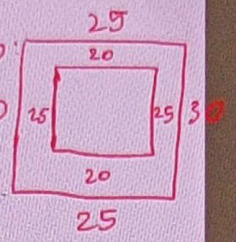
$= 36\ \%$

$\Rightarrow$ % of extraction $\Rightarrow \frac{25 \times 30 - 20 \times 25}{25 \times 30} \times 100$

$\Rightarrow \frac{750 - 500}{750} \times 100$

$\Rightarrow \frac{250}{750} \times 100$

$\Rightarrow 33.33\ \%$



Panels

- A panel is a district separated from other districts by a barrier which may be of solid coal or of brick stoppings
- In case of an emergency arising from spontaneous heating, out break of fire in the panel, heavy gas emission, crush of pillars etc. the panel can be sealed off by brick stoppings and isolated from the other workings
- The coal barrier between adjacent panels is usually of the same thickness as the thickness of pillar
- The number of pillars in a panel is such that during the depillaring stage the coal from the pillars can be extracted to the maximum percentage within the incubation period which varies from seam to seam and is usually between 3 to 10 months
- The number of pillars varies from 12 – 30
- Long panel is sub divided into small panels during depillaring by construction of isolation stoppings

Opening out a district

- Heading is driven in the dip rise and level directions
- Manner of opening out districts depends upon
  - Mode of entry into the seam whether by an incline or by a pit
  - Type of transport system for the districts
  - Gradient of the seams
  - Nature of coal, whether liable to spontaneous heating or not
- In an inclined mine using rope haulage the direct rope haulage is the main transport and it is along the true dip except in steep seams
- It is best to have least number of air crossings in the roadways leading to the district and it is also desirable to avoid doors or brattices on the haulage roads and to arrange for ascensional ventilation

19:50

Development of districts

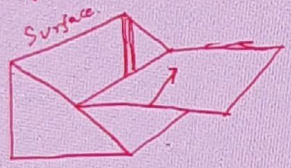
By – Devendra Singh Tomar

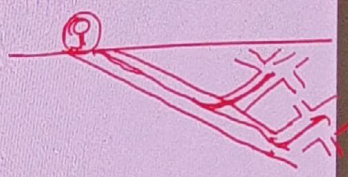
Development by cross cuts

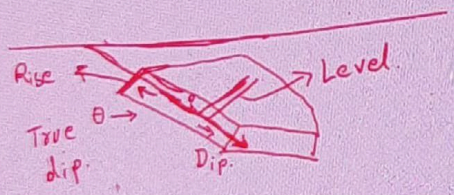
- Development of the area to the dip side of the shaft level or prominent haulage level by cross cuts is a common practice
- In many mines as one direct haulage can work in the main dip as well as in the cross cut. The seam should be inclined and the gradient in the cross cut should not be less than 1 in 12, the limiting gradient for direct haulage.
- On milder gradients the empty tubs, when lowered, are not able to pull the rope of the haulage engine and trammers have to drag it, often on their shoulders. This seriously affects the output.

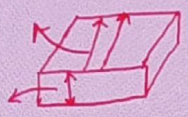
True Dip → max.m angle of dip on a rock bed

Apparent dip → angles other than true dip.

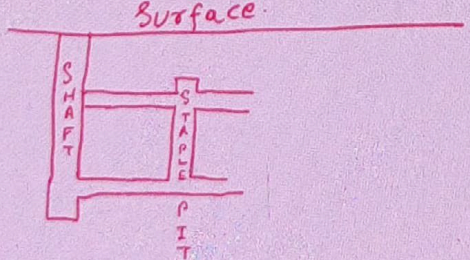








Staple Pit / blind shaft → यह एक Vertical shaft होता है जो कि एक U/g working को दूसरे U/g working से connect करता है।



- Cross cuts not only save the number of haulage engines but also help to develop the area on the strike when the main dip is advancing and for this reason a cross cut should make a

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- Cross cuts not only save the number of haulage engines but also help to develop the area on the strike when the main dip is advancing and for this reason a cross cut should make a sufficiently large angle with the main dip, provide the gradient of the former is suitable for operation of the direct haulage.
- In a seam of mild gradient cross cut is not an advantage.
- Cross cuts to the rise side are uncommon for haulage purposes.
- One direct haulage works along the main dip and the same haulage operates for the crosscut

- A panel is opened from the main dip and another from the cross cut so that development on the strike in the panel off the crosscut takes place at the same time when the main dip and cross cuts also progress and prove a large area in advance.
- Two cross cuts, one going East and the other going West, branching off from the main dip
- In the district opened on the strike from the cross cut the upper levels have to advance a good distance before a tugger or tail rope haulage can be installed in a dip-rise gallery.
- It is, therefore, common practice to have only a few pillars (usually 3 or 4) in the dip-rise direction in a crosscut district.

Development in steep seams

- The methods of development by bord and pillar, so far stated, are suitable for working seams upto a gradient of 1 in 4.
- Special arrangements have to be made in working seams steeper than 1 in 4.
- The special arrangements are as follows:-
  - The main haulage or conveyor should be, not along true dip, but along apparent dip to reduce the gradient of the road
  - The coal pillars should have smaller dimension along the dip and larger dimension along the strike.
  - The level galleries should be joined, not along true dip but along apparent dip. The pillars, therefore, become rhombus shaped. The floor area of each pillar should be the same as the area required of a pillar at that particular depth. The acute angle of the rhombus pillar should not be small, otherwise the corners may crush.
  - Except the haulage dip the cross-connections between levels should be staggered. Otherwise a sleeper or other material rolling down a cross-connection would roll down to the lowest level without any hindrance.
  - From the main haulage road, tram lines should be taken to each level.

- Steps should be provided not only in dip galleries, but also in level galleries as the floor of the scam is steeply inclined and not suitable for walking.
- In the dip or rise galleries where the loaders have to carry coal in baskets to the tramming level, in addition to steps, hand bars should be provided.
- Face pumps should be trolley mounted.
- If chain conveyors are used at the face, the conveyors in the level galleries should be on the rise side.
- Other equipment like drill transformers, gate end boxes, etc., should also be kept on the rise side in the level for the same reason.
- The coal tubs or mine cars should be of special design to prevent spillage when hauled along the haulage plane.
- While laying out a haulage track in the level gallery, the floor should be blasted as it is inclined and the blasted rock may be utilised for packing of the tram line.
- Movement of the track towards the dip side of the level gallery is sometimes

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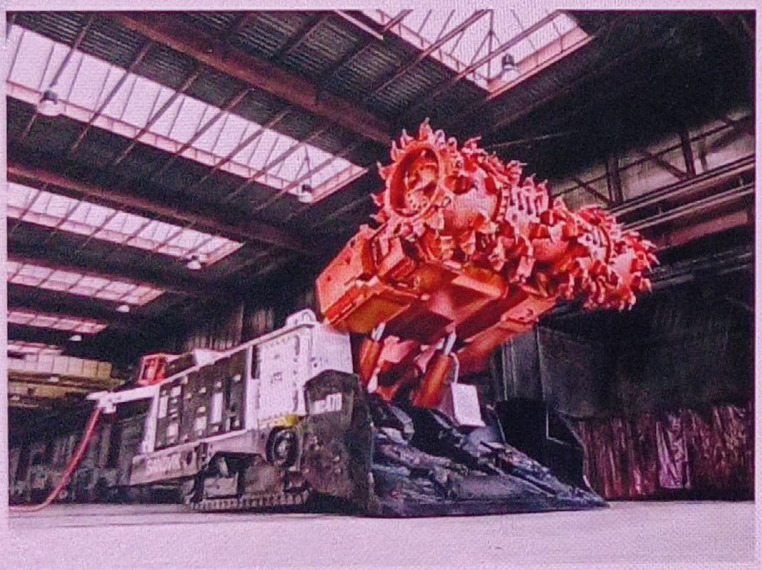
Production

By – Devendra Singh Tomar

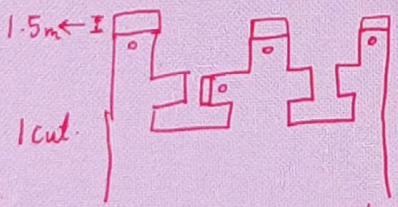
MINING GYAN

Output available from one district

- It is assumed that coal cutting machines are used.
- The average number of faces in a district with a number (n) of headings is (2n-1).
- With 3 headings, 5 faces and with 5 headings, 9 faces are normally available for working
- Out of these, one or two faces are generally stopped for roof or side support.
- Each face receives one cut per shift under normal working conditions with skid mounted coal cutters.
- If the haulage track or chain conveyors are close to the face (say, within 6 m), it is possible to get 4 cuts in 4 shifts at the same face
- With a 1.8 m long jib of coal cutter the average depth of cut comes to 1.5 m under good supervision.
- In a gallery of 4.2 m width and 2.1 m height the output per cut is 17 te under ideal conditions, but rarely more than 14 te are available because of the floor coal left during operations of coal cutter



Main headings



In 1 shift 1 m/c will give 1 cut.

Total 4 machine in 8 shift

Total no. of cuts ⇒ 12 → 24 hrs i.e in 1 day.

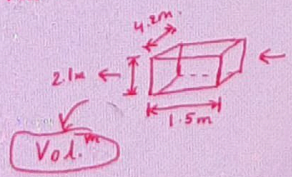
Production per cut ⇒ width x height x depth x Sp. gr.

⇒ 4.2m x 2.1m x 1.5m x 1.3

⇒ 17.199 te.

⇒ 14 te

Sp. gr. 2



Total cuts → 12 cuts in 1 days.

Total production in 12 cuts ⇒ 12 x 14 ⇒ 168 te.

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Total cuts → 12 cuts in 1 days.
Total production in 12 cuts ⇒ 12 × 14 ⇒ 168 tc.

District headings

5 headings → 8 faces have cutting m/c.
output on an average is 15 te in 1 cut
1 m/c gives 1 cut per shift
Total their are 3 shifts
Calculate production of 1 day.
Production → 8 × 3 × 15 = 360

Main reasons for low output

- At the face
- On the track and haulage planes
- On the surface

At the face

- Face is not properly prepared for the coal cutting machine.
- Floor coal is not removed and the effective height is less.
- The depth and width of the cut are less due to bad manner of sumping in and cutting.
- It is a good practice to start coal cutting from one end of the panel and proceed from face to face to the other end. This reduces the time wasted on flitting.
- Insufficient attention to blasting

19:56 | 03:46 0.03 KB/s 4G 73

- Insufficient attention to blasting
- The time lost after blasting for the smoke to clear up
- Efficiency of manual loaders. Bad lighting and bad ventilation, congesion of the galleries with brattices and equipment, reduced height of the roof due to cross bars, etc. affect the efficiency of manual loaders.

On the track and haulage planes

- Hand tramming wastes the energy and time of the trammers and loaders. Moreover turn-over of tubs becomes low.
- Proper gradient of the tracks, their packing, smooth curves, check rails, etc. do not receive enough attention with the result that derailments take place
- Often the number of tubs available to a district is limited due to poor turnover of tubs in circulation
- Sometimes D-Links or couplings on the tubs are missing and the tub has to be kept out of use or the train length is reduced
- Bad planning at loading ends underground

① Hand Tramming
↓
waste of energy & Time.
+
Poor Turnover
↓
Less no. of tubs in Circulation.

② Tracks.
↓
Gradient
Packing
Smooth Curves
Check rails.
} Derailment
↓
Poor attention.

③ Missing D-links or Couplings. (To join the tubs)
↓ ↘
Tubs Rejected. Train length reduced.

On the surface

- When wagons are not available for loading, tipplers discharging on the screening plant are not used unless storage bunkers are provided. In such cases loaded tubs are often emptied by hand at dumping yard. This process is slow and turnover of tubs is seriously affected.
- During manual emptying the tubs which are tipped end-on or side-on, sometimes roll down the coal bank. They have to be brought back on the track. In an ill supervised mine such tubs are known to get buried under coal and this reduces their number in circulation.

On surface
=
→ Wagons are not available ↔ Loading / Tipplers } screening plant में discharge कर दिया जाता है।

On surface

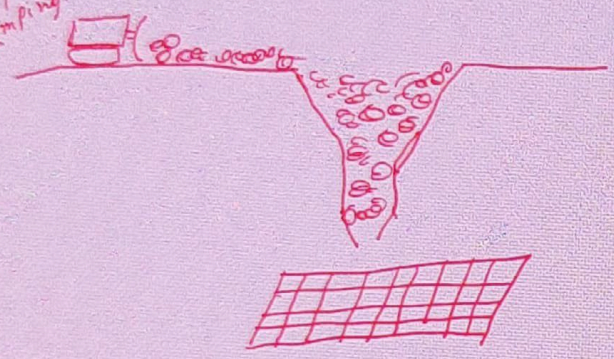
→ Wagons are not available → Loading, Tipplers } screening plant में discharge बंद कर दिया जाता है।

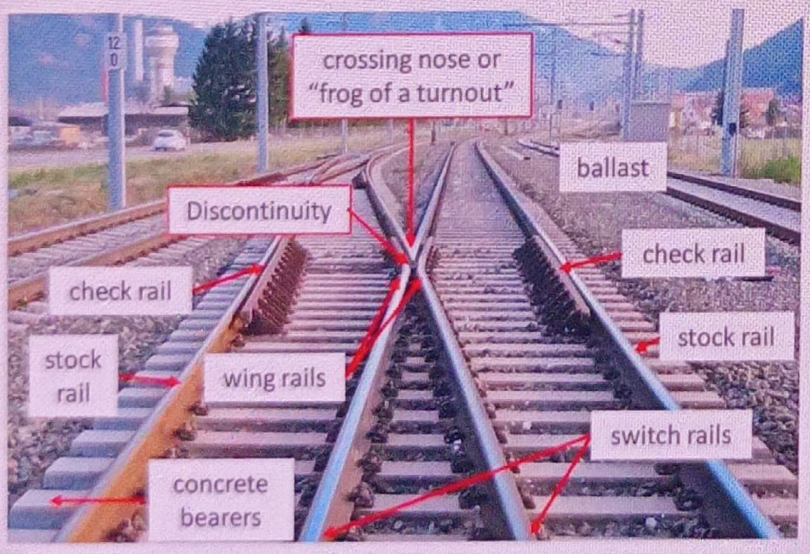
Bunkers → Loaded tubs को by hand dumping yard में खाली कर देते हैं

Effect → Slow, Poor Turnover

→ Manual emptying → end on, side on } Tubs roll down the Coal bank → Bring Back on Track.

Dumping





Output available with solid blasting

Progress in 1 blast ⇒ 1m → advance, depth, Pull.

4 blasts from 1 face in 24hrs (3 shifts)

Progress in 4 blast ⇒ 4m

Gallery ⇒ width ⇒ 4.2m

height ⇒ 2.1m

Output available with solid blasting

Progress in 1 blast ⇒ 1m ⇒ advance, depth, Pull.

4 blasts from 1 face in 24 hrs (3 shifts)

Progress in 4 blast ⇒ 4m

Gallery ⇒ width ⇒ 4.2 m
height ⇒ 2.1 m

Coal available in 1 blast ⇒ width × height × Pull
⇒ 4.2 × 2.1 × 1
⇒ 8.82 m^3 [solid]

Coal available after minor losses ⇒ 8 m^3 (assume)

Coal available after 4 blasts ⇒ 8 × 4 ⇒ 32 m^3 in 24 hrs. from 1 face

30 m^3 ← after minor losses

District ⇒ 3 headings.
4 faces are available

Output ⇒ 30 m^3 × 4 = 120 m^3 from 1 district.

Total we have 3 districts ⇒ output ⇒ 120 × 3 ⇒ 360 m^3

Output in tonnes ⇒ 360 × 1.3 ⇒ 468 te.

Q ⇒ Gallery ⇒ height ⇒ 2.5m
width ⇒ 4m.
Pull ⇒ 1.2m. ⇒ per blast

5 heading district ⇒ (3n − 2) ⇒ 13 faces ⇒ 10 faces are always available

Sp. of Coal ⇒ 1.5

[Avoid Minor losses]

Total districts ⇒ 5

Productions in 24 hrs.?

No. of blast per days ⇒ 6 blast from 1 face.

19:58 06:24 0.00 KB/s 72

Output & Layout

By – Devendra Singh Tomar

Layout for locomotive & mine cars

- In a nearly flat seam using locomotives, mine cars, gathering area loaders and trolley mounted coal cutter.
- The galleries are nearly 4.8 m wide and the pillars rhombus-shaped (60°/120°) for easy turn round of the locomotive at corners.
- The junctions with the main heading are staggered to minimise roof exposure.
- One of the galleries with track is used by locomotive as siding for keeping the empty or loaded mine cars.
- The skid mounted coal cutter is not a matching equipment where locomotives are used as the yield of coal by such coal cutter in a shift due its slow speed of flitting and cutting is insufficient for transport by locomotives.
- Indeed a coal cutter which gives a face advance of less than 2 m per cut is not considered a matching equipment for transport by locomotives.
- The track of mine cars is always kept nearly touching the face for the coal cutter. If the face advance per cut is 2m, track length (simple multiples of 2m), such as 2m, 4m and 6m, are depth ready as extension pieces.
- The mine cars may be loaded by manual loaders or by gathering arm loaders.

→ Locomotives used in flat seams.
  ↳ Mine Cars
  ↳ Loaders
  ↳ Trolley mounted Coal Cutter

→ Locomotives के case में → if width of gallery is 4.8m.
  ↳ Then Pillars. → Rhombus shape (60°/120°)
    ↳ for easy turning at corners

→ Main heading & Junctions → Staggered → To minimise roof exposure.

→ One gallery with track. is for empty & loaded mine cars

- Nearly similar layout with rhombus shaped pillars is adopted where shuttle cars are used in combination with mechanical loaders or continuous miners and a belt conveyor provides the main transport.
- The shuttle car does not discharge directly on the belt conveyor, but into a small bunker or hopper which releases the coal on the conveyor by a chute.
- The operating distance of the shuttle car is limited to 180 m due to restriction on the length (90 m) of the trailing cable. Where the distance between the face and the hopper exceeds 90 m, the driver has to disconnect the trailing cable from the gate end box during the middle of the run and reconnect it to cover the remaining distance.
- In a developing panel it is possible to give 8-12 cuts per shift (trolley mounted coal cutter) yielding about 200 te in the shift.

→ Skid mounted Coal Cutter का Use तभी होता है
  ↳ if locomotives are used.

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→ Skid mounted Coal cutter का Use ना करें।
↓ if locomotives are used.
↓ because
① flitting speed is slow.
② cutting is insufficient for transport by locomotives.

→ Mine cars → loaded by
↙ Manual Loading
↘ Loaders. (SDL & LHD)

→ Similar layout with rhombus shaped Pillars.
↓ Combinations → shuttle cars – mehanical Loaders.
→ Shuttle cars – belt conveyors.
↓ discharge → small bunker, hopper } on conveyor by chute.

→ operating distance of shuttle cars → 180 m by

Restrictions on development of a mine

- Vertically below and within 45 metres of a railway, road, public works buildings and permanent structures not belonging to the mine owner.
- below a river, canal, tank or surface reservoir and also within 15 m from either bank of a river, canal or boundary of a lake or tank.
- Within 7.5 m of the common boundary of a mine.
- If the boundary is disputed, within 7.5 m of the boundary claimed by owner of a neighbouring mine.
- Within 60 m of any disused or abandoned workings containing water.
- Seams lying above or below a fire area.
- At any place with a cover of less than 15 m.

Restrictions

within.
7.5m ⇒ common boundary of mine.
15 m ⇒ below water body.
⇒ cover less than 15m.
45m ⇒ vertically below ⇒ surface structures
60m ⇒ water logged disused/ abandoned working

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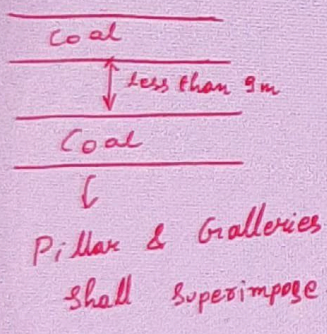
45m ⇒ Vertically below ⇒ Surface structures

60m ⇒ water logged disused/abandoned working

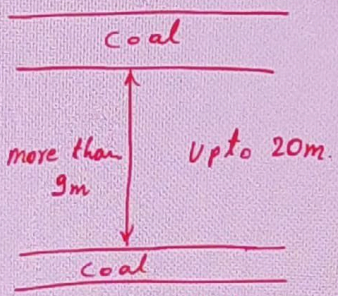
→ Seams above or below fire areas.

Working of contiguous seams

- If two seams are separated by a parting of less than 9 m they are known as contiguous seams.
- Their working, if both have to be worked at a time or one after another, needs prior approval of the D.G.M.S.
- A thick seam may be worked in two sections, one at the floor and the other near the roof and the parting between any two such sections of a thick seam or between two contiguous seams should be not less than 3 m thick.
- If the seams are within 9 m of each other, the pillars and galleries in one seam should be vertically above or below the pillars and galleries in the other seam if they are not steeply inclined.
- This condition is not applicable if the parting is more than 9 m.
- Where the seams are not contiguous but separated by a parting upto 20 m thick, their development in panels is often planned in such a way that the panel barriers are vertically above or below those in adjacent seams but the pillars and galleries inside the panels are not vertically coincident.
- To ensure verticality of pillar over pillar it is recommended that top and bottom seams should be under the charge of the same overman.
- The thickness of the parting should be ascertained from time to time by drilling boreholes at junctions of galleries after alternate pillars.



Pillar & Galleries shall superimpose.



Barrier pillars shall superimpose.

- In a thick seam if there is any band of stone, shale or inferior coal which is not workable economically, such band is allowed to remain in the parting between adjacent sections so that the thickness of parting is brought up to 3 m or more.
- Such bands help to maintain definite floor and roof gradients and nearly uniform thickness of section under development.
- They also help in reducing the roof convergence.
- When working contiguous seams development of bottom-most seam is usually in the dip direction for water consideration and development in other seams is in other direction, i.e. towards the rise or strike so that the property is proved during development stage.
- One haulage may serve both the seams through a drift. In such a case output from the seams can be brought to one seam, preferably the lower seam, from where it is hoisted up.
- A pit is normally sunk upto the bottom seam and coal of top seam is lowered by jig arrangement to the bottom seam.
- It is a common practice to keep the bottom seam advanced at least one pillar ahead of the top seam and water of the top seam is allowed to gravitate to bottom seam though bore holes or a drift so that top seam workings are dry.
- From the bottom seam the water is pumped to the surface or to the main sump.
- Ventilation of contiguous seams may be through a staple pit or through a drift.

Depillaring

MINING GYAN

By – Devendra Singh Tomar

Depillaring

- The operation for extraction of coal from pillars is known as pillar extraction, depillaring, pillar cutting or broken working
- Two basic methods of depillaring are:-
  - Caving method
  - Stowing method
- Caving method – The coal of the pillars is extracted and the roof is allowed to break and collapse into the voids or the de-coaled area, known as goaf.
- Stowing method – It is a method of pillar extraction in which the goaf is completely packed with incombustible material.

Caving Method → Cracks develop on Ground surface.
↳ Subsidence.

① depends on depth of seam
② Thickness of seam.
③ Nature of strata.
④ Thickness of subsoil
⑤ effect of drag by faults.

Adoption of depillaring with stowing

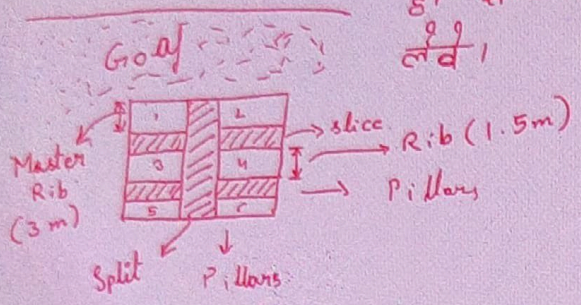
- Presence of water-bearing strata above the coal seam being extracted
- Enormous quantities of water beyond the economic pumping capacity may enter the mine through cracks in the strata
- Railways, rivers, roads, etc. situated on the surface, which cannot be diverted.
- Presence of fire in a seam above the seam to be extracted
- Existence of one or more seams of marketable quality extractable in the near future
- Restrictions imposed by local or Government authorities for the protection of the surface
- Extraction of the full thickness of a seam thicker than 6 m, as thicker seams cannot be extracted fully by caving method
- Extraction of seams very prone to spontaneous heating, of very gassy nature or liable to pumps
- Surface buildings which cannot be evacuated
- Tanks, reservoirs, etc. which cannot be emptied.

Stowing is not Possible.

Stowing is not Possible

↓

Splitting method → Coal के pillars में gallery drive करते हैं और कोशिश करते हैं कि जितना ज्यादा हो सके उतना Coal निकाल लेवें।



Preparatory arrangement for depillaring

- There is the least danger to the safety of the mine and the men employed underground or on the surface
- Maximum possible extraction is achieved
- Extraction of other seams or sections of seams is not rendered difficult
- The extraction is economic
- Dangers from crush or collapse of pillars, fire, influx of noxious gases, or inundation are avoided
- Effect of fire or water-logged areas in the adjacent mines has also to be considered. Before undertaking depillaring operations, permission has to be obtained from the D.G.M.S.
- Diversion of railway, stream, road, power transmission lines, telephone lines, aerial rope way, etc. has also to be considered
- Rehabilitation should receive attention
- Surface land likely to subside has to be purchased. All these arrangements take 1-2 years.

Depillaring operation की planning इस तरह से करें कि :-

1. Mines & men को कम से कम danger हो।
2. Max.m extraction is achievable.
3. others seams or sections में extraction करते समय कोई भी problem ना हो।
4. Extraction is economic.
5. Dangers from Crush or collapse of pillars.
6. Effect of fire or water logged areas in adjacent mines

Before starting depillaring operation.

1. Take permission from DGMS.
2. Take permission from Railways, if their is a railway line above it.
3. Take permission from District Authorities
   ↓
   if District Roads, buildings will get affected.
4. Purchase land which may get subsided.

MINING GYAN

Caving method

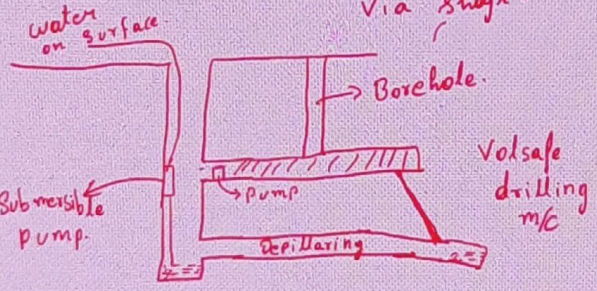
By – Devendra Singh Tomar

Preparatory for caving method

- If there is a seam above, developed and filled with water, or "goafed" and water logged, it has to be dewatered
- In case the top seam is developed, and abandoned temporarily, pumps can be installed in it for dewatering
- Top seam may be dewatered through a shaft if it is on the dip side and is accessible on the surface.
- The shaft may be equipped with a submersible borehole pump
- In most of the cases of depillaring of top seam the shaft pillar might have been extracted and the access road to it on the surface subsided
- Under such circumstances pumps cannot be installed in the top seam and its dewatering is by boreholes drilled from bottom scam workings
- Such borehole drilling calls for accurate surveying
- The boreholes should be made by a drilling machine like the VOLSAFE drilling machine which can control flow of water during drilling
- Dewatering of the top seam from the bottom flow of water during drilling
- Dewatering of the top seam from the bottom seam may be done in stages if the depillaring in bottom seam is to proceed from rise to dip

→ water logged area को dewatering करना है। उसके depillaring करने वाली जगह के ऊपर water logged area है तो।

→ Dewatering → Installation of pumps → To the surface Via shaft.



Plans ⇒ ① New Constructions
② Position of boreholes
③ Position of staple pit
④ Position of fault planes & dykes in the leasehold
⑤ Goaf of mines & adjacent mines

⇒ History of adjacent mines → operations. → Manager, Overman, Surveyor
↓
DGMS → adjacent abandoned mines.

⇒ Plans ⇒ Panels
⇒ Pillars to be extracted
⇒ Sequence of pillar split
⇒ Pillars to be left intact
⇒ Pillars to be extracted shall be numbered with red colour.

Plans

- The plans are brought upto date showing all the new constructions, position of boreholes,

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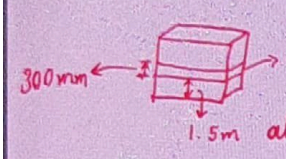
Plans

- The plans are brought upto date showing all the new constructions, position of boreholes, staple pits, etc.
- The position of fault planes and dykes in the leasehold and also in the area of an adjacent colliery should be shown
- The goaf area of all these seam in the same mine and the goaf areas of the adjacent mines also should be indicated
- History of mining operations in the adjacent mines should be ascertained from role experienced Managers, overmen or surveyors.
- Sufficient allowance should be made for inaccuracies in the plans which may be intentional or unintentional
- Plans and history of the adjacent abandoned mines will be available from the office of the D.G.M.S.
- The thickness of barrier in adjacent mines that have been depillared should be treated with caution as the barrier might have been "robbed" during retreating though the plan adequate thickness
- Plans of the area to be depillared are prepared on a large scale showing the panels, the shows pillars to be extracted, the sequence in which pillars have to be split and extracted, and the pillars to be left intact.

Pillars to be left intact → mark a band of limewash of 300mm width all around the perimeter and 1.5m above floor



Tracings of plans → Under manager
↓
overman
↓
Mining Sirdar.

⇒ if Make of water is more than pumping capacity
(Seepage)
↓
Inform Manager & RIM

⇒ Adequate no. of supervisory staff, workers & specially who have experience in depillaring.

⇒ Stock of materials.
① Timber
② Fire fighting equipment.
③ Fire sealing equipment → ① stone dust ② Bricks ③ lime cement ④ C G I sheet (corrugated galvanised) ⑤ Flame proof brattice cloth
④ Helmet & shoes

- Pillars underground should be numbered with red lead and the pillar to be left intact should be marked all round the perimeter with a band of limewash 300 mm wide at a height of 1.5 m from the floor
- Tracings of such large plans should be given to the under managers, overmen to the mining sirdars
- The adjacent mines likely to be affected by depillaring, mines on the dip side that will have to pump extra water, have to be informed
- Adequate number of supervisory staff, workers and specially the mines who have experience of depillaring, have to be appointed; strength of timbermen may have to be increased
- There should be adequate stock of the following materials

have experience of depillaring, have to be appointed; strength of timbermen may have to be increased

- There should be adequate stock of the following materials
- Timber:- The demand is heavy during depillaring. In a thick seam the size of props normally not required during development will be in demand during depillaring. Construction of cogs requires logging sleepers in a large number
- Fire fighting equipment and fire sealing equipment e.g. stone dust, bricks, lime, cement, C.G.I. sheets, flame proof brattice cloth, etc.

⇒ Increase → no. of tubs in circuit
→ haulage capacity
→ strength of trammers.
→ Pump Capacity.

⇒ Installation of timbers supports & chock supports.

⇒ Make artificial panels by stoppings

⇒ Frame systematic timbering rules

⇒ Provide at least 2 escape routes to the surface.

- Protective equipment like helmets, hoes, etc.
- Production during depillaring is likely to be high and the magazine capacity, number of tubs in circuit, haulage capacity and strength of trammers may have to be increased
- Capacity of pumps should be increased to deal with extra water coming underground through surface cracks
- Outbye pillars have to be stabilised by sand stowing or substantial timber supports, chocks.
- Isolation stoppings must be constructed to form artificial panels of convenient size Within which any heating or fire caused during depillaring may have to be confined and sealed. "Sized of artificial panels should be such as to complete the extraction within the incubation period.
- Systematic timbering rules are to be framed and explained to the supervisory staff and timbermen. A copy of the rules, suitably illustrated, has to be posted at conspicuous places in the mine. Systematic timbering is compulsory in depillaring areas.
- In a mine every working place, where practicable, should be provided with at least two ways affording means of escape to the surface
- The fact should always be borne in mind for depillaring districts where the operations are usually hazardous.

Caving method

By – Devendra Singh Tomar

Seam thickness upto 3m

- The pillars formed during development are split into small pillars called stooks which are then extracted one by one.
- A gallery driven in the pillar for this purpose is called a "split".
- At shallow depth, below 100 m depth, pillars during development are small and they can be extracted without splitting.
- Generally, a pillar greater in size than 18 m x 18 m is split up into two stooks.
- In a large pillar of 30 m x 30 m size between centres, one split 3.5 m wide in the middle of the pillar along the strike and another split of similar width in the middle of the pillar along the dip, are driven so that the pillar is divided into 4 stooks.
- The splitting may start from 4 middle points of the pillar simultaneously.

Depillaring by Caving

(a) Thickness upto 3m

(b) Thickness 3m to 6m → Thick. seam mining

Stook ⇒ Small pillars that we get on splitting of pillars.

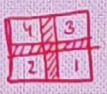
Split ⇒ Gallery driven from a pillar

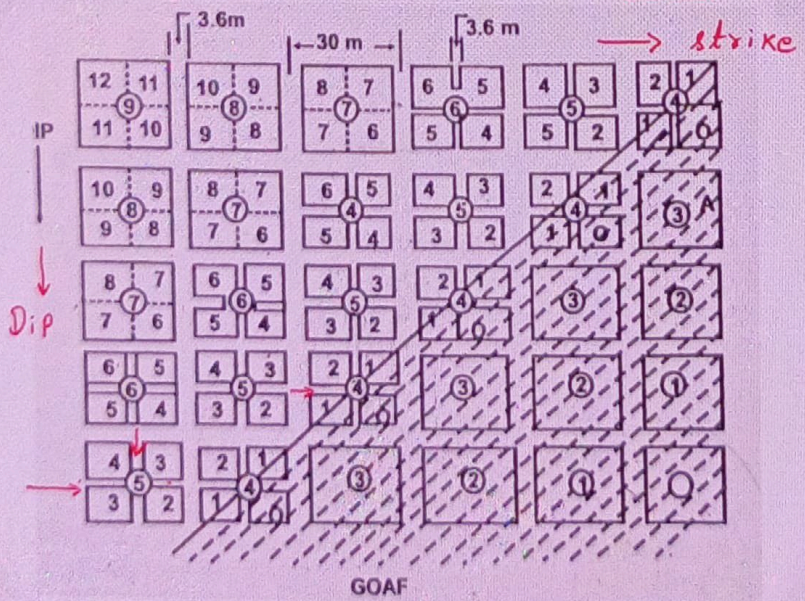
⇒ In shallow depth mines (upto 100m) → splitting is not required

⇒ width of split → 3.5m

⇒ Split is from the middle of pillar → along the strike / along the dip.

↓ we will get 4 stooks





- The Coal Mines Regulations permits splitting of a maximum of four pillars when pillar extraction is about to begin.

GOAF

- The Coal Mines Regulations permits splitting of a maximum of four pillars when pillar extraction is about to begin.
- The width of split gallery should not exceed the width of development galleries at that depth (Reg. 111).
- Once the pillar extraction is commenced, the splitting of pillars may be done upto 2 pillars (maximum) ahead of the pillar under extraction.
- During development, height of a gallery does to exceed 3 m.
- If the seam is thick, the development galleries and the split galleries are heightened so that all the coal upto the roof is removed using portable wooden stools to stand on.
- If the roof consists of shale, 0.6 m thickness of coal is left intact in the roof as shale has a tendency to part from roof rocks when exposed to atmosphere for some days.
- Props are erected generally 1.2 m apart and cogs 3 m apart for roof support.

According To CMR 2017 → Reg. No. 112

→ when extraction of pillars is about to begin in a district

↳ Splitting / heightning → maximum 4 pillars एक साथ

→ Once the pillar extraction is commenced

↳ Splitting and heightning → of pillar under extraction है उसके बाद के 2 pillars तक

- Due to weight of roof on the pillars their coal is loosened and can be obtained easily by miner's picks without blasting.
- A pillar 30 m size from centre to centre is generally 26 m corner to corner.
- Splits of 3.5 m width give stooks of nearly 11m x 11 m.
- The miners attack the stook from the side remote from the goaf or barrier so that the coal in the stook always stands between the miner and the goaf and protects him from the falls of roof in the goaf

⇒ width of split gallery ⇒ equal to width of gallery during development. / ~~उससे~~ अधिक नहीं होना चाहिए

⇒ Height ⇒ not more than 3m

⇒ In thick seam → heightning can be done upto roof. Coal from the roof can be removed

⇒ width of split gallery ⇒ equal to width of gallery during development. / ~~इससे~~ अधिक नहीं होना चाहिए

⇒ Height ⇒ not more than 3m

⇒ In thick seam → heightning can be done upto roof & coal from the roof can be removed by using portable wooden stools

⇒ if roof consists of shale ⇒ shale gets affected due to mine atmosphere
⇒ 0.6m thickness of coal is left in the roof

- At one time 3 to 4 such stooks are under extraction and the other miners are employed on splitting and gallery heightening jobs.
- During extraction of coal a rib about 1 metre thick is left against the goaf.
- When all the slices are removed, and the area is to be abandoned, the rib coal is "robbed" to the maximum extent possible.
- When no more coal is extractable from the stooks, without endangering safety, props and roof supports are withdrawn and the area is then abandoned.
- Chocks are at goaf edges and the area is fenced off.

⇒ Support ⇒ ① Props ⇒ at intervals of 1.2m } for roof
② Cogs ⇒ at intervals of 3m } support

⇒ Attack the stook ⇒ from the side remote from the Goaf or barrier
⇒ i.e. oppisite to goaf

20:13 KB/s MINING GYAN

Stook method

By – Devendra Singh Tomar

Stook method

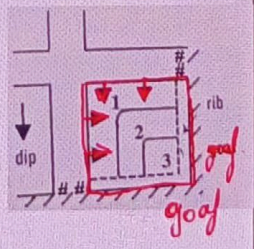
- In the process of depillaring, pillar formed during development is split in 2 to 4 pillars, depending on its size, to limit the area of roof exposure
- These parts of pillar are known as stooks
- Stooks are then extracted one by one
- A stook can be extracted by 3 methods

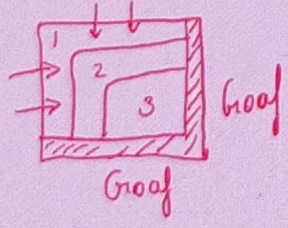
⇒ How many minimum no. of stooks will be formed on splitting of a pillar?
Ans ⇒ 2

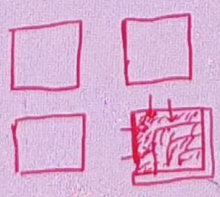
⇒ How many maximum no of stooks can be formed on splitting of a pillar?
Ans ⇒ 4

⇒ How many stooks can be formed on splitting of a pillars?
Ans ⇒ ① 2 to 4
⇒ ② It depends on the size of pillar.

⇒ Attacking the entire stook method.
① Roof is good
② Leave a rib against goaf
2m







Attacking the entire stook

Attacking the entire stook

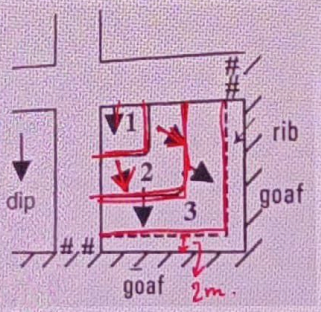
- Where roof is good
- Leaving a rib of 2m against goaf, the stook is extracted from two sides
- On return, the rib is thinned down as much as safety permits

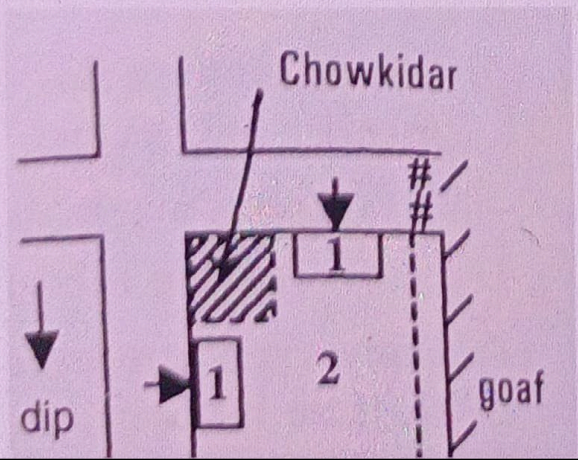
Half moon method

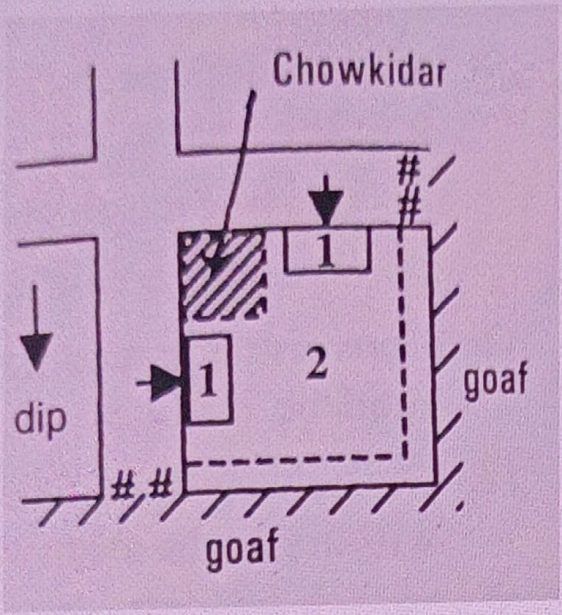
- For good roof
- Stook is attacked from the corner in half moon fashion, leaving 2m ribs against the goaf.
- In the end, these ribs are thinned down as much as is safety possible

⇒ Half moon method
⇒ for good roof

⇒ Fender method (Chowkidar)
↳ bad roof
↳ fender ⇒ 10m × 10m.







Fender method

- For bad roof
- Leaving a 10m*10m fender at the corner, and a 2m rib against goaf, the stook is attacked from two sides
- On return the ribs are thinned out as much as safety permits and in the end the fender is taken out by half moon method

Behaviour of roof & its control

- When the galleries are widened or heightened, or splits formed, the equilibrium of pressure that had stabilised during development stage in the strata overlying the seam and immediately below it is affected and the re-adjustment of pressure causes roof movement.
- When the stook or pillar is extracted, such roof movement is more pronounced due to the removal of the support so far offered by the solid coal of stook or pillar.
- Sudden transfer of pressure to any pillar or stook may result in crushing and the aim during depillaring is to avoid sudden accumulation of pressure over standing pillars or stooks and the supports erected outbye the goaf edge.
- Once the roof movement sets in, the kinetic energy is difficult to control by supports.
- During depillaring, no splitting or reduction of pillars or heightening of galleries should be done beyond a length of two pillars ahead of the pillar under extraction.
- Galleries which are heightened or widened should be supported by rows of props, 1.2 m apart and by chocks 3 m apart.

• Behaviour of roof & its Control during Depillaring

⇒ Roof re-adjustment करेगा pressure का
↓
इसके कारण roof movement होगा

⇒ जैसे ही stook or pillar को extract करेंगे
(suddenly) pillars or stook

इसके कारण roof movement

⇒ जैसे ही stook or pillar को extract करेंगे तो पूरा pressure (suddenly) pillars or stook पर आ जाएगा ↓

Pillars / stook will get crushed.

⇒ Crushing of the pillars is known as overriding of pillars.

- Chocks are necessary at junctions of the galleries, or splits and at goaf edges.
- Systematic timbering rules specify the manner of supports and the spacing of supports.
- Supports should be erected without delay in the void formed due to pillar extraction, leaving enough room for movements of workers, swing of tools, movement of tubs, etc.
- Even when supported by timber the area exposed should be kept to a minimum.
- With a good sandstone roof, the area explored may not be more than 40 m^2 at one stook extraction.
- With 3 or 4 stooks under attack at one time, the total area should not exceed 900 m^2.
- Each case, however, should be decided on the experience gained about the nature of the roof and its behaviour.
- The roof strata are relieved of the accumulate pressure energy when the pressure breaks up the roof.
- Once such energy is dissipated in the breakage of roof the pillars are not under stress and working conditions are comparatively safe.
- It is therefore, necessary to see that the roof in the goaf area is induced to fracture at regular intervals.
- The Regulations require that the depillaring operations should be conducted in such a way as to leave as small as area of uncollapsed roof as possible, and there possible, suitable means shall be adopted to bring down roof in the goaf at regular intervals.

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MINING GYAN

Roof control

By – Devendra Singh Tomar

⇒ Behaviour of roof during depillaring

Effects of depillaring on roof → ① Re-adjustment of pressure in roof

$KE = \frac{1}{2}mv^2$ $PE = mgh$

where,
m = mass
v = velocity of object
g = acc.^{n} due to gravity
h = height of object.

② sudden transfer of pressure → stook → others pillars support

③ if movement of roof is set → due to KE → difficult to control by support

→ Galleries which are → heightning, widening, Splitting } support is to be Provided

Prop (1.2m) Chock (3m)

→ Support कब करना है ?

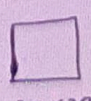
↓ without delay after void is formed due to pillar extraction

① Junctions
② Splits
③ Goaf edges

⇒ Leave space for → movement of workers, swing of tools, movement of tubs, movement of machine

⇒ Exposed area of roof ⇒ it should be minimum
↓ after Providing support
⇒ Without support
↳ max.^{n} => $90m^2$

not more than $40m^2$ → at one stook
not more than $900m^2$ → for 3-4 stook



$900m^2$

⇒ It should be decided on the basis of experience

⇒ Exposed area of roof ⇒ It should be mimimum
⇒ without support
↳ max.^{m} ⇒ $90m^2$

↓

after providing support

↳ not more than $40m^2$ → at one stook

↳ not more than $900m^2$ → for 3-4 stook.

30×30

$900m^2$

⇒ It should be decided on the basis of

↳ ① experience.

↳ ② Nature of roof & its movement.

Regulations → leave as small as uncollapsed roof.

→ Apply suitable means to bring down roof.

① withdrawal of supports → roof will break due to pressure of strata.

② Induced blasting → In the roof

③ Changing line of goaf or line of face.

Premature Collapse ⇒ Support withdraw करने पर roof normally collapse करती है

MINING GYAN

Regular roof fracture

By – Devendra Singh Tomar

Ensuring regular roof fracture

- The prop, when tapped with a stick, produces a dull and drummy
- The lid over the top of the prop bends
- The prop buckles in the middle or at weaker points in its length
- If the floor is soft, the prop may penetrate it
- There may be rumbling sound in the goaf
- If a small crack existed in the roof and a wedge is hammered in it when supports a erected, the wedge becomes loose and falls as the crack widens when the roof pressure increases and roof tends to come down
- In some cases water percolation from the roof takes place as the cracks widen. This is the first indication of roof movement
- Intermittent fall of loose rock piece from the roof in goaf increases, and small coal pieces shoot off the sides
- Booming sound of roof movement increases
- Heaving of floor is noticed

⇒ Withdrawal of supports → Omechanical prop withdrawer

→ Hammer should not be used

→ ③ Goaf के पास वाले props को सबसे पहले withdraw करना

→ ④ Goaf में इक भी support नहीं छोड़ना

↓

It will retard regular roof break.

⑤ Props को withdraw करने के पहले chock से support कर दें

↓

goaf edges

⑥ fence off the goaf edges after Prop withdrawal.

Withdrawal of supports

- All the props and chocks have to be withdrawn only by mechanical prop withdrawer
- Hammer should not be used
- No supports should be left in the goaf in erected position as they retard the regular roof break
- If a prop cannot be withdrawn it may be destroyed
- The chocks should be erected at the goaf edges before prop withdrawal and the openings outbye the goaf edges should be

they retard the regular roof break

- If a prop cannot be withdrawn it may be destroyed
- The chocks should be erected at the goaf edges before prop withdrawal and the openings outbye the goaf edges should be strengthened by erection of props and bars
- Such goaf edges should be fenced off after all the timber is withdrawn

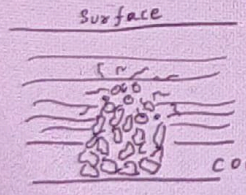
Local fall

- After withdrawal of timber unsupported roof tends to fracture
- The lower strata of the immediate roof separates and fills the goaf
- The fall which takes place soon after withdrawal of supports is called local fall
- If the roof is well stratified sandstone or shale, the local fall takes place within 24 to 48 hours of the withdrawal of timber
- Such local fall does not extend to the surface and the rocks within a height of only a few meters above the seam is affected

Local fall ⇒ Support withdraw करने के बाद unsupported roof में fracture होते हैं

The fall which takes places soon after withdrawal of supports

⇒ if roof is of sandstone or shale
↳ local fall 24 to 48hr within of withdrawal



⇒ It does not extend to the surface

Air blast

- When the roof fall takes place, the air in the goaf area is displaced by the broken roof rocks
- The intensity of the air blast depends upon the volume of the air that is displaced
- If the immediate roof is massive sandstone or has a sill, the local fall does not occur for long period even after withdrawal of supports
- The volume of air gets displaced when the roof fall is large

Precautions against air blast

- Extensive area of uncollapsed goaf should not exist at a time. Bring

Precautions against air blast

- Extensive area of uncollapsed goaf should not exist at a time. Bring down the roof at regular intervals if possible
- In any depillaring district, all the workers should be withdrawn to a safe place when the usual indications of imminent roof fall are observed
- Apart from the entries for ventilation and haulage, additional roadways should be kept open in a thick seam
- Before every air blast switch off electricity because air causes suspension of coal dust in air
- Construction of few isolation stoppings with an easily breakable zone should receive attention

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Roof falls

MINING GYAN

By – Devendra Singh Tomar

Main fall

- When the area of extraction is nearly equal to or more than, the square of the depth, the cracks due to depillaring extend upto the surface.
- The roof fall which affects the surface is known as main fall and takes place long after the first roof fall in the depillaring district.
- If the seam is at a shallow depth air leaks through the cracks to the coal buried in the goaf and is responsible for spontaneous heating
- The main fall is expected if:-
  - Area is near a fault plane
  - If the upper seam has been depillared

After roof fall → Examine the place
- working places
- goaf edges

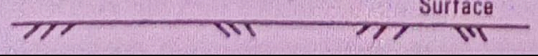
} Mining Sirdar

To avoid air blast due massive sandstone roof
- ① withdraw all supports
- ② Leave one or Two props.
  - Indicator → Weight of roof
  - Mining Sirdar → Goaf के edge पर खड़े होकर Porch की help से props को check करेगा

Main fall → Roof fall which affects the surface.
- यह local fall or first roof fall during depillaring उसके बाद होता है।

When main fall occurs → Ar. of extration is equal to or more than square of depth of seam.

Main fall is expected if:-
① Area is near a fault plane
② If the upper seam been depillared



depillaring

When main fall occurs → Ar. of extration is equal to or more than square of depth of seam.

Main fall is expected if:-
1. Area is near a fault plane
2. If the upper seam been depillared

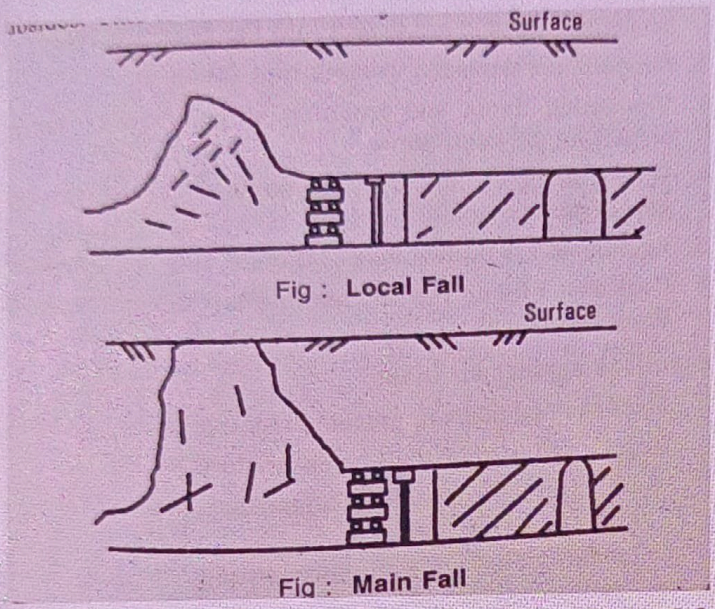


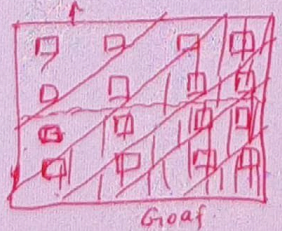
Fig : Local Fall

Fig : Main Fall

Effects for depillaring near vicinity of fault

- More precautions for roof control
- Water seepage may take place near fault
- Emission of gas may take place near fault
- The line of goaf should not be parallel to the fault, but nearly at right angles
- Heavy roof fall and even premature collapse may take place if line of goaf is parallel to the fault
- The unsupported roof may slide along the fault plane
- It is a sound practice to leave some barrier of solid coal near the fault

Effects of depillaring → near vicinity of fault
1. More precautions for roof control
2. Water seepage
3. Emission
4. Premature collapse → line of goaf is ⊥ to the fault.



Precautions

MINING GYAN

By – Devendra Singh Tomar

Line of goaf

- A line passing through all the corners of stooks under extraction at a time is called line of extraction.
- It is sometimes loosely called "line of face" or "line of goaf".
- A line of extraction which is diagonal, i.e. nearly 45° to the dip direction
- With such line of extraction each pillar contributes some portion of it towards roof support
- One solid stook intervenes between two stooks under extraction at a time.
- The line of goaf is more inclined towards the strike than in the earlier case.
- Where roof is bad, the presence of once solid stook between two stooks under extraction gives good support to the roof
- As the stooks are extracted, the intervening stook is subjected to heavy pressure and its crushing indicates roof weight
- Steep diagonal line of goaf may be so arranged in some cases as to have two solid stooks in between the stooks under extraction

Line of Goaf

→ Extraction के समय stooks के corner के पास होने वाली line

↳ Line of face or line of Goaf.

Types of line of extraction

① Diagonal line of extraction → nearly 45° to the dip direction

② straight line of extraction

③ step diagonal line of extraction

Bad roof → one solid stook b/w 2 stooks under extraction → gives good support

↓

Heavy pressure → Its crushing indicate roof weight.

→ V-line of extraction shall be avoided

→ Straight line of extraction → reduces lead for manual loaders

→ reduces no. of conveyors

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roof weight.

→ V-line of extraction shall be avoided

→ Straight line of extraction → reduces lead for manual loaders
→ reduces no. of conveyors

→ Line of extraction ll to strike
↳ advantage → goaf can be submerged in water
↳ if depillaring from dip to rise → seam is inclined

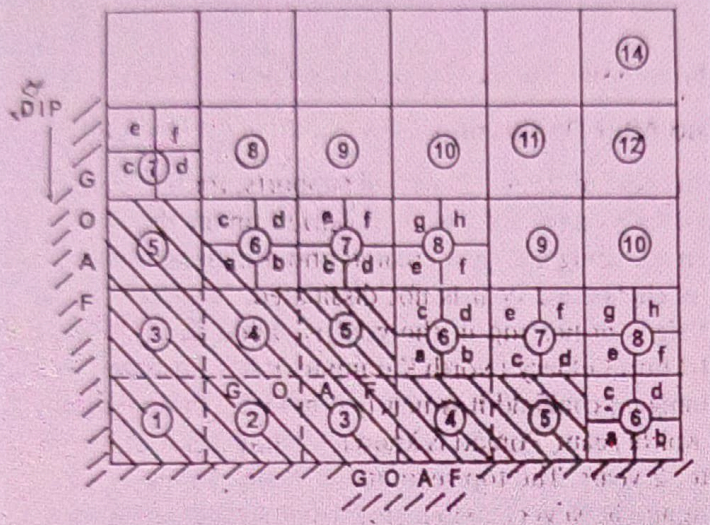

Fig. 12.3 Step diagonal line of face

- A line of extraction that forms as arrowhead in the goaf should be avoided
- The pillar or stook at the arrowhead is under excessive pressure and is liable to be crushed
- Where conveyors are used in a depillaring district, it is necessary to have a straight line of extraction so as to reduce the number of conveyors and lead for manual loaders
- A line of goaf parallel to the strike has the advantage that the goaf can be submerged in water if the depillaring is proceeding from dip to rise and the seam inclination is not mild

→ Provides large no. of faces

→ Depends on behaviour of roof
↳ जो stook under extraction है उसके बाद वाला unworked stook support provide करता है।

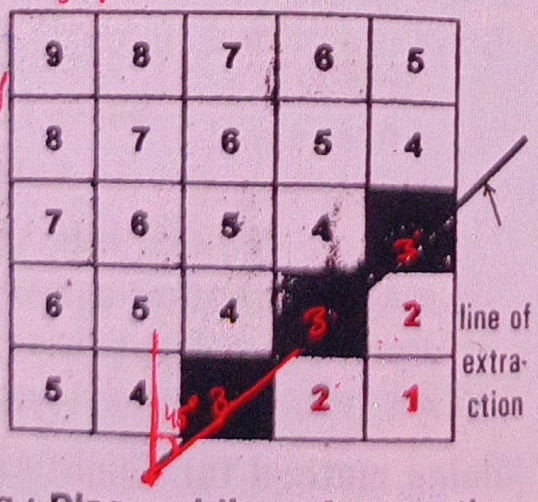

Fig : Diagonal line of extraction

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→ Provides large no. of faces

→ Depends on behaviour of roof

↓

जो stook under extraction है उसके बगल वाला unworked stook support Provide करता है।

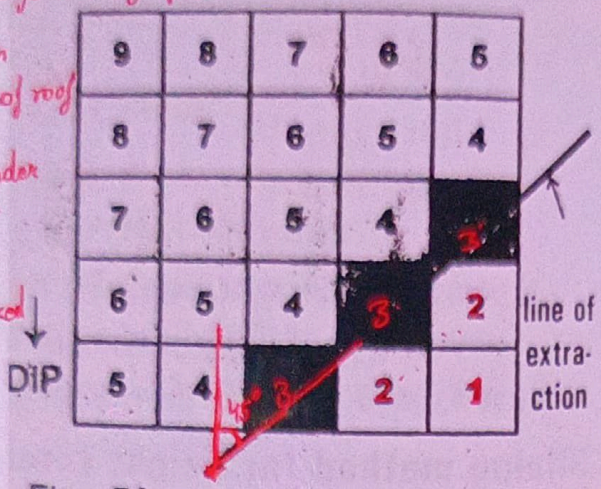

Fig : Diagonal line of extraction

→ Roof is hard and difficult to cave

→ Along the or // to strike

→ stowing method

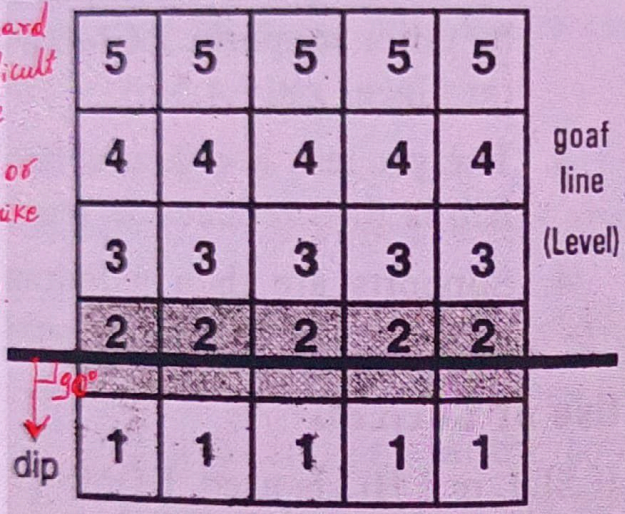

Fig : Straight line of extraction

→ one stook b/w 2 stook under extraction.

→ weak roof

→ best for hydraulic stowing

↓

facilitates water drainage

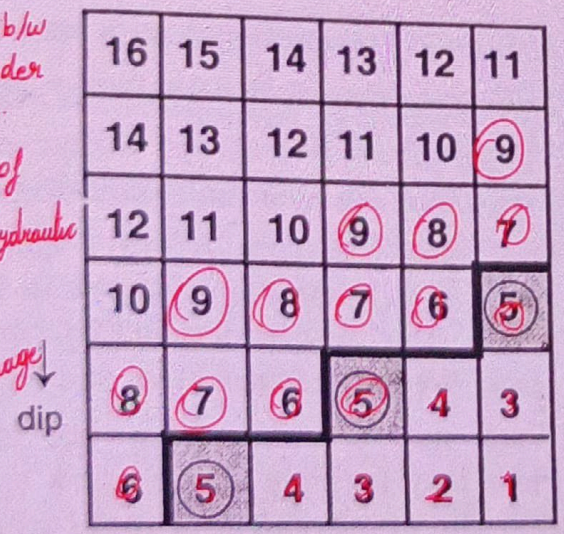

Fig : Step-diagonal line of extraction

→ Arrowhead line of extraction

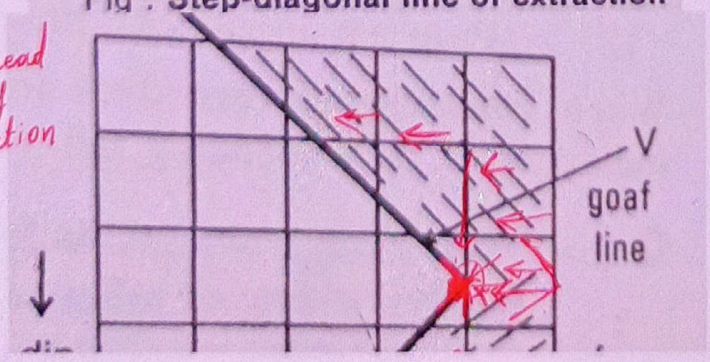

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Fig : Step-diagonal line of extraction

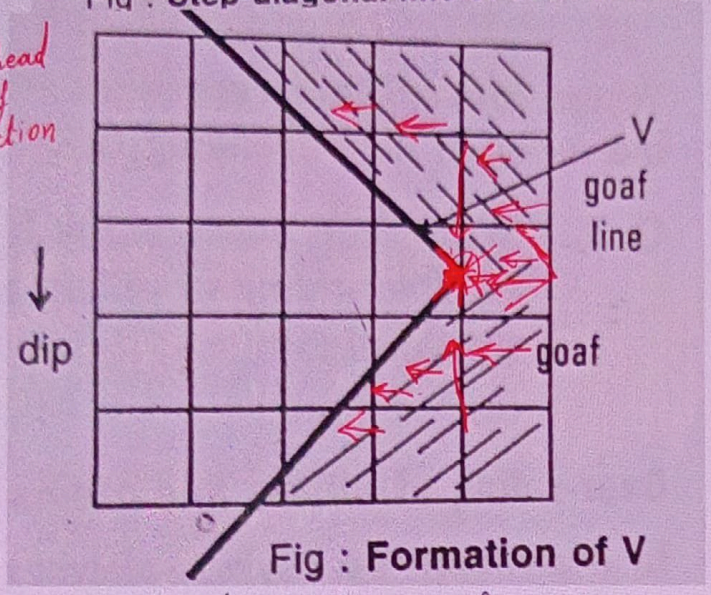


Fig : Formation of V

Precautions against fire

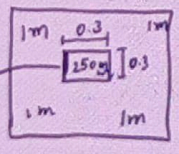
→ On support withdrawal
↓
Coal falls from → roof
→ fenders
→ Partially extracted stooks
↓
It gets burried under roof fall
→ Spontaneous heating की condition create हो जाएगी

→ Steps to prevent sp. heating in goaf.

① Depillaring in panels.
↓
no. of pillars depend on incubation period.

② Isolation stopping → In deg. 1 → 1m thick of brick in lime or cement.
↓
It should have a weak zone.
↓
0.3m × 0.3m → Thickness 250mm
↓
at centre.

To protect from air blast.
↑
Weak Zone.



→ deg. 2 or 3 ⇒ It must be explosion proof
↓
1 wall → Thickness not less than 1.8m.
↓
2 walls → Thickness not less than 1m each with a 4.5m gap in b/w
↓
filled with Incombustible matter → Sand or boiler ash.

Incombustible matter
↑

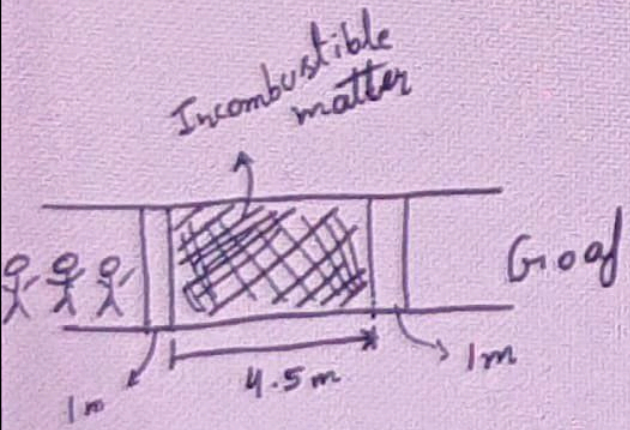
→ deg. 2 or 3 ⇒ It must be explosion proof

↳ 1 wall → Thickness not less than 1.8 m.

↳ 2 walls → Thickness not less than 1m each with a 4.5m gap in b/w

↓

filled with Incombustible matter → Sand or boiler ash.



(3) Depillaring from dip to rise.

↓

In case of Inclined seam.

↳ To submerge goaf under water.

↓

Black damp (CO_2) gets collected over it.

Prevents oxidation of fallen coal.

(4) 100% extraction of coal.

Contiguous seams & Bumps

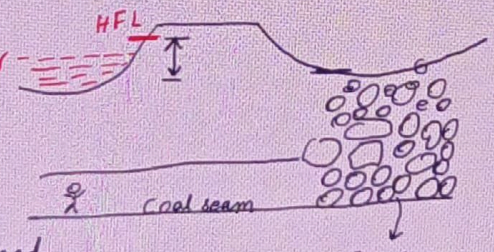
By – Devendra Singh Tomar

Precautions against Innundation During Depillaring

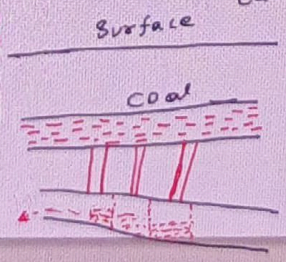
→ Make accurate plan
→ When depillaring zone is within 60m of water logged area
↳ drill advance borehole at any angle.
(Burn side borehole m/c)
→ Below water logged area → No depillaring
→ Overlying water bearing strata
↓
Adequate pump capacity → Then only caving
→ Subsidence below HFL → No depillaring

Subsidence कभी भी HFL से नीचे नहीं होना चाहिए

HFL ⇒ Highest Flood level

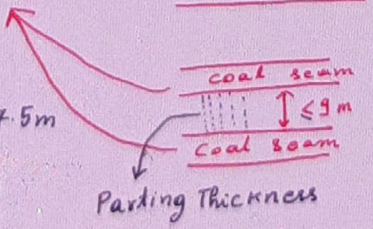


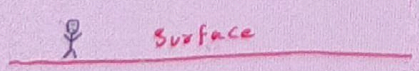
→ If top seam is water logged
↓
① Dipillaring from Rise to dip
② Dewatering in stages.

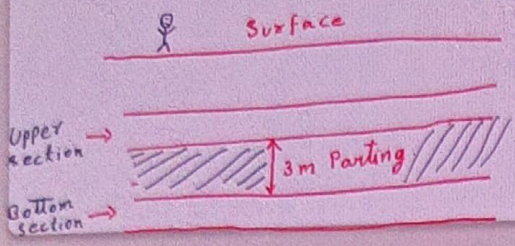


Depillaring Contiguous Seams

→ It depends on parting thickness
→ If seam thickness is more than 7.5m
↓
worked in 2 sections (Parting 3m)

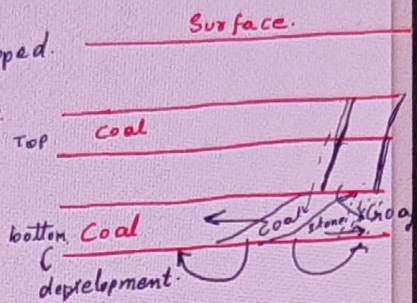






→ If stone Parting

① 1m thick → 1 seam is developed.
- fan cut.
- stone parting is thrown in goaf.
- bottom / Top

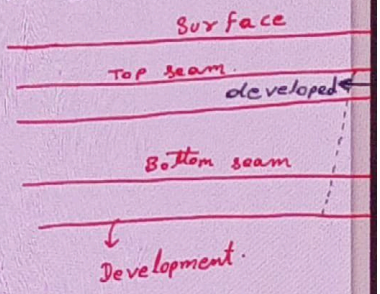


② 1m to 3m

ⓐ दोनों seams में एक साथ depillaring करते हैं
Line of goaf vertically coincident होना चाहिए

ⓑ bottom seam को develop करना है
Top seam में एक drift drive करना है

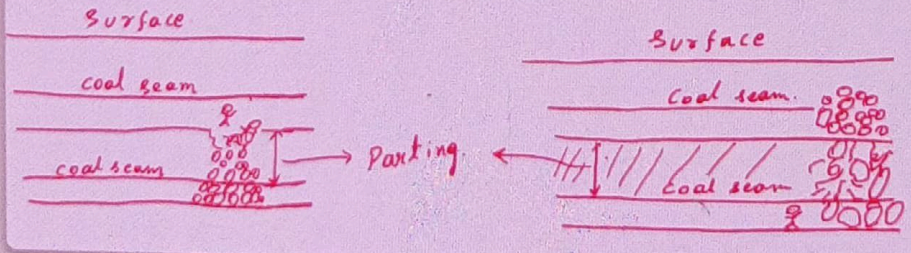
- drift drive करके seam के end तक जाना है।
- developed upto 2 pillars & then extracted



Support withdrawal.

① if top seam support withdrawn first it may puncture parting

② if bottom seam support withdrawn first it will collapse top seam.



③ More than 3m ⇒ both seams are developed with pillars vertically coincident

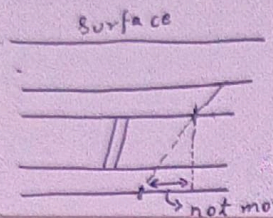
(3) More than 3m ⇒ both seams are developed with pillars vertically coincident

⇒ Depillaring is simultaneous

⇒ Line of goaf not more than 2 pillar ahead in top seam.

⇒ Two seams shall be under same overman

⇒ good communication system.
↳ by a borehole ⇒ 18mm dia pi
↳ ⊙ Telephone
@ Signalling bells



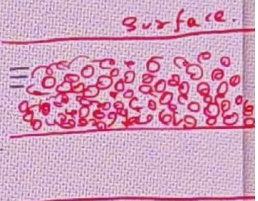
Working below goafed area (For parting more than 9m)

⇒ Extraction in lower seam should be conducted under settled goaf.
↳ ऐसा जिसमें किसी प्रकार का movement नहीं है।

⇒ steps against inundation from water logged top seam goaf.

⇒ if top seam is goafed ⇒ main fall is quicker
↓
Plan accordingly.

⇒ Heavy timbering ⇒ due to dead weight of top seam goaf.

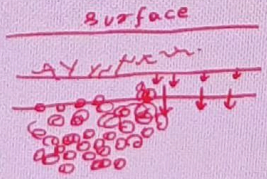


Working over Goaf of a lower seam

⇒ Work over settled goaf
or
Parting must be 30m or more.

⇒ अगर bottom seam के depillaring के वक्त top seam के development करते तो bottom seam में depillaring करने पर top seam के roof में cracks develop हो जाएंगे।

due to movement of strata.



Bumps

⇒ Sudden violent bursts of coal from pillars
↓ air blast ↓ shooting of coal pieces
Gas may also release

① Shock bump → when roof of goaf does not fall
↳ on breakage of Cantilever roof.

Bumps

⇒ Sudden violent bursts of coal from pillars
- air blast
- shooting of coal pieces.

Gas may also release.

① Shock bump → when roof of goaf does not fall
↳ on breakage of Cantilever roof.

② Pressure bump → when roof of goaf does not fall
↳ roof pressure compresses the pillar
↳ compressibility खत्म होने पर pillar break होता है।

Conditions for occurence of bumps.

① Strong & brittle coal, that does not crush easily.
② Depth more than 150m.
③ Strong overlying rock strata / sandstone roof overhangs in goaf.
④ Strong floor rock that does not heave.

↳ Nature

⑤ Improper mining method → planners of mine working.

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Methods of mining

Chapter – 13 Lecture 1

MINING GYAN

Longwall & other methods of Mining.

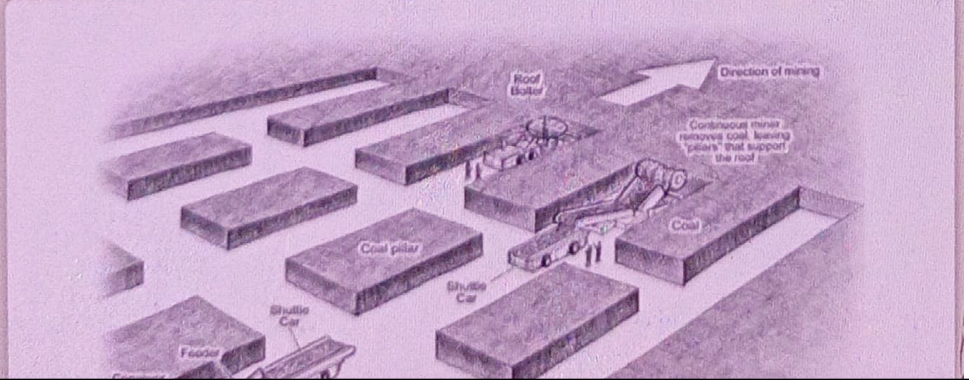
→ Room & Pillar / Bord & Pillar mining

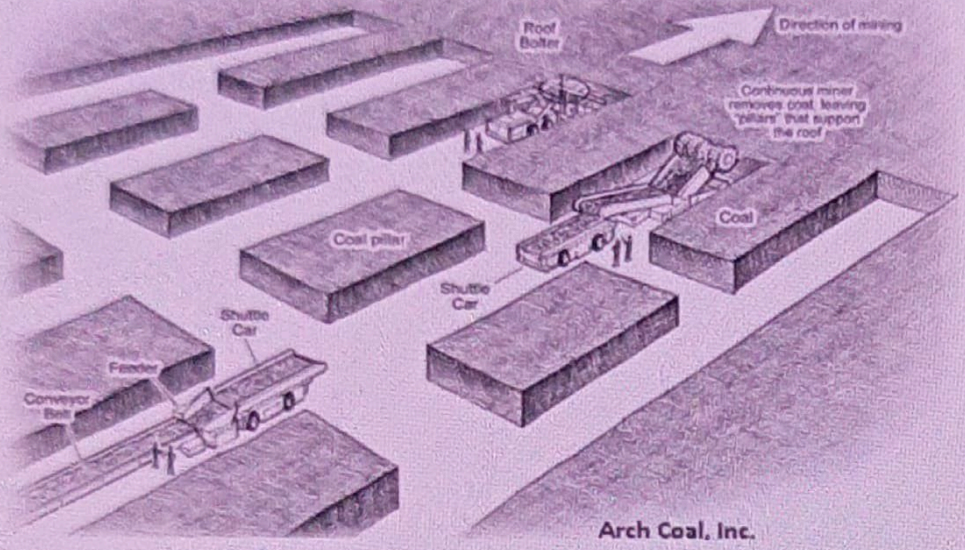
→ Longwall mining
- Longwall advancing
- Longwall Retreating

→ Horizon mining
→ Inclined slicing
→ Sublevel

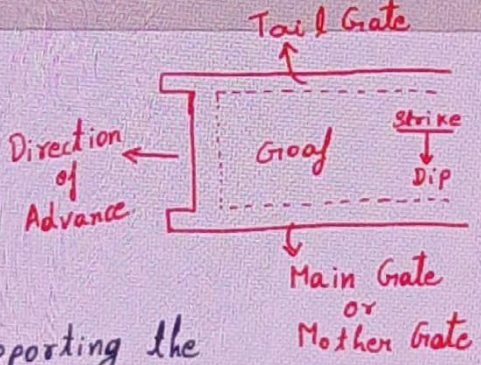
Room & Pillar Mining

→ Similar to B & P method
→ Popular method of America
→ Applicable for thin seams
→ Rooms are generally constructed as wide as Possible
(depends on roof stability)
→ Room width → 4.5m – 7.5m
→ Pillars → Length → 6 – 12 m
→ width → 12 – 27.4m
→ Rooms are supported by roof bolts





Longwall Mining



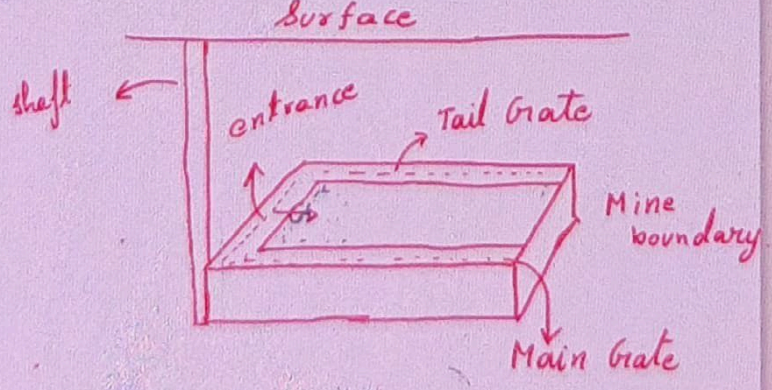
→ face ⇒ 60 - 200m.
↓
Void is left behind
advances in one Direction

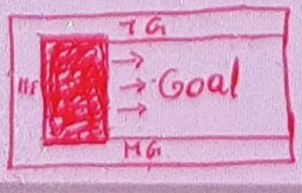
→ Pack walls ⇒ walls of stone supporting the roof of goaf
↓
Sand or Crushed stone

→ Support → Timber, steel props, bars or Chocks.
↓
3m-6m width ∥ to face is supported.

Main Gate & Tail Gate

↓
In case of Longwall advancing
↓
secured by pack walls & chocks.





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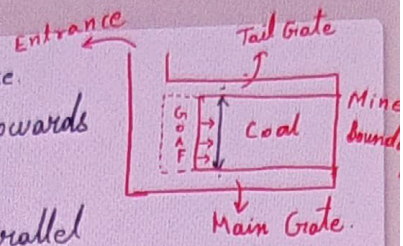
Youtube Links For Longwall

Longwall Advancing



→ Extraction of coal from shaft towards entrance or boundary of mine or panel

→ face तक पहुंचने के लिए roads drive करते हैं

parallel → Main Gate, Tail Gate

distance b/w them = face length.

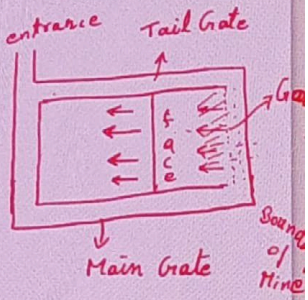
→ Roof over Goaf ⇒ Supported by Pack wall or sand stowing or Caving is done.

Longwall Retreating

→ extraction of coal is done from mineboundary towards mine entrance/shaft.

→ Pairs of roads are driven in Solid Coal
↓
Upto predetermined boundary
↓
Connected by longwall face

→ Goaf Packing not requ



Gate Roads ⇒ Roads at either end of face

① In case of haulage as transport.

Main gate → Intake airway
→ for Coal transport (haulag gate)

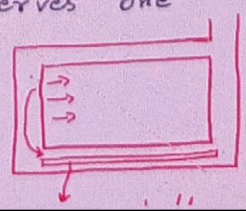
Tail gate → Return airway.

② In Case of conveyor belt as transport.

Main gate → Intake airway

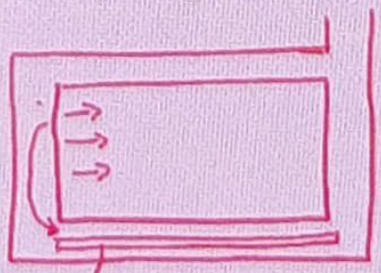
Tail gate → Return airway
→ Coal transport (supply gate)

Single Unit face → Gate belt Conveyor serves one longwall face



Double unit face ⇒ Gate belt Conveyor Centrally situated

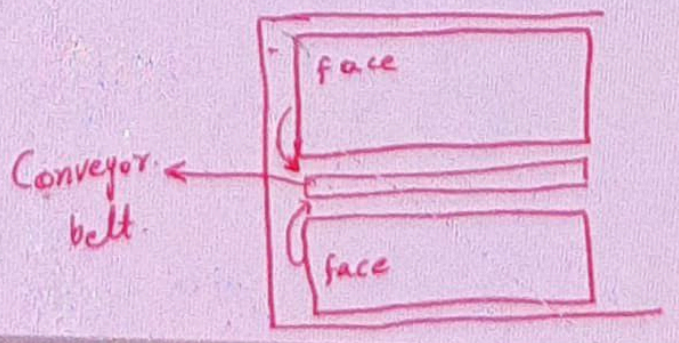
Single Unit face → Crate belt Conveyor serves one longwall face



Double unit face ⇒ Crate belt Conveyor

↓ Centrally situated

serves two longwall faces.



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Longwall mining Terminologies

① Face ⇒ long front from which coal is extraction

② Tail gate / Supply gate ⇒ Roadways used for supply of material & Return air.

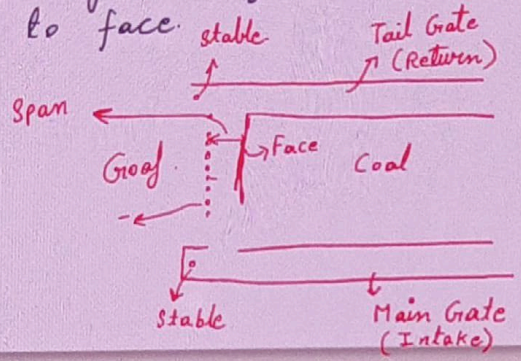
③ Main gate / haulage gate ⇒ Roadways used for transport of Material & Intake air

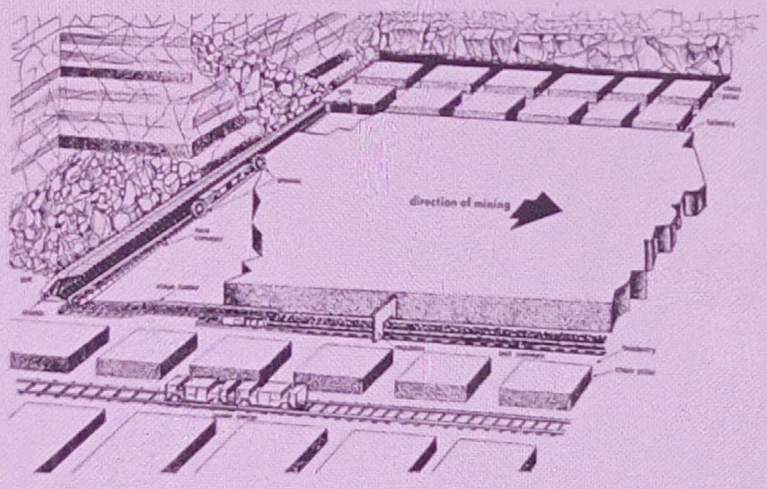
④ Goaf line ⇒ The line along which roof is intended to cave

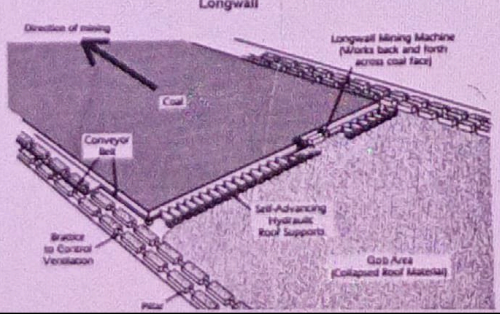
⑤ Stable ⇒ A portion at the end of face specially prepared to accomodate the machine to cut the face

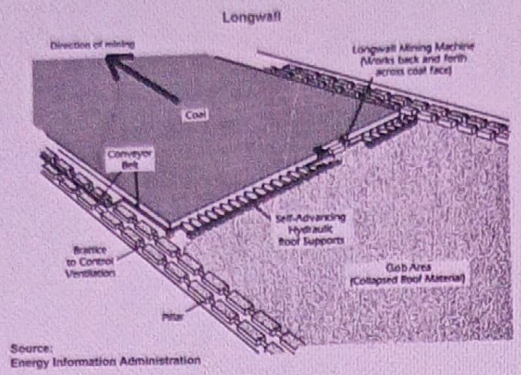
⑥ Butlock ⇒ The portion at the end of the face from where cutting is started

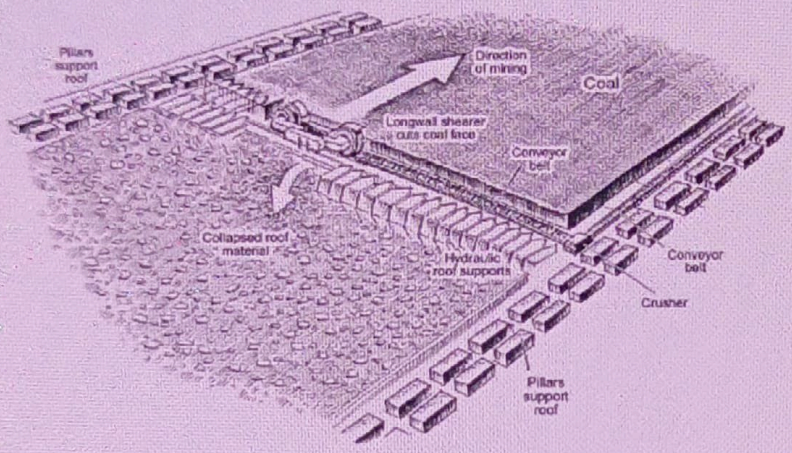
⑦ Span ⇒ The width of working from goaf line support to face.











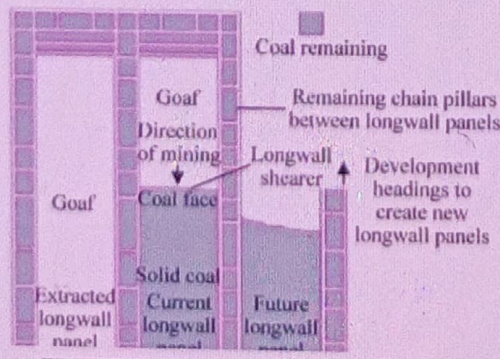
Gate Roads → in either direction

→ Tail Gate (Return airway)

→ Main Gate (Intake airway)

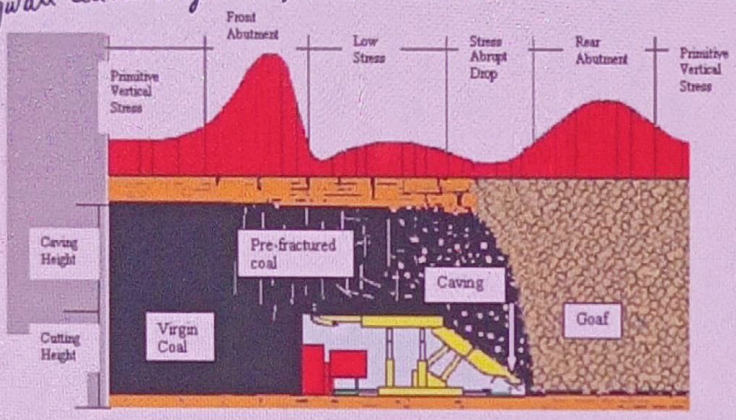
Rope haulage (Main gate) → Nil → Transport of coal & Supply of material

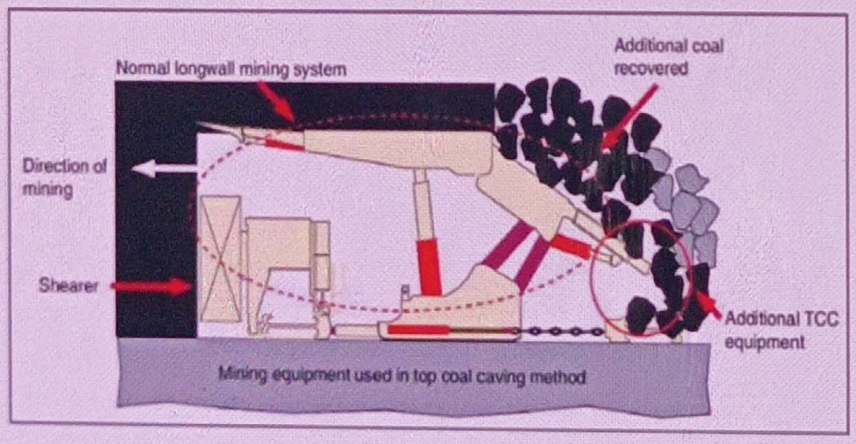
Conveyor (Main gate) → Supply of material (haulage) → Transport of coal



Advantages of Longwall mining.

→ It is simple & concentrated work areas.
→ Capable of high production, good supervision.
→ All seams extracted in one operation, max.m extraction %.
→ Easy Ventilation.
→ Roof weight acts on face – looses Coal.
→ Dirt bands → Goaf packing.
→ Few roads to be taken.
→ Seams liable to sp. heating can be worked
↳ all the Coal can be extracted.
→ Least Capital cost per tonne of annual output.
↳ Longwall advancing → quicker return.

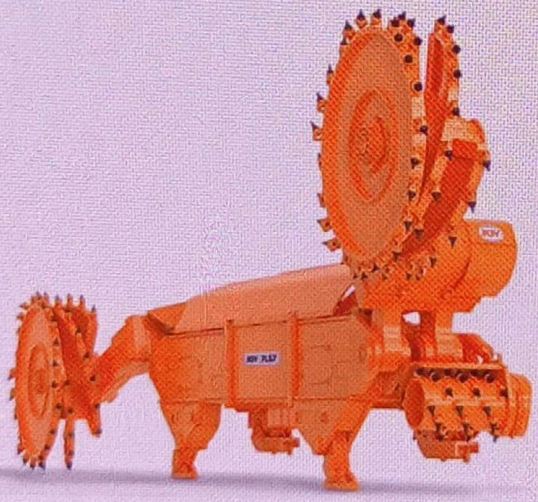




Disadvantages of Longwall mining.

→ Maintenance of roads for long.
→ Longwall advancing with caving → large goaf left behin
↳ danger of firedamp.
↳ if packing not well Ventilation leakage problem.

→ Longwall advancing with caving → large goaf left behind
↓
danger of firedamp.
if packing not well ventilation leakage problem.



Application.

→ Thin seam (as thin as 0.7m)
→ Seams with dirt bands.
→ Seams with tough roof / weak friable roof.
→ Contiguous seams, if solid packed.
→ Grassy seams
→ Seams to be mechanised for large outputs.

Length of longwall face

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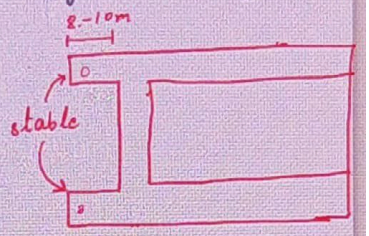
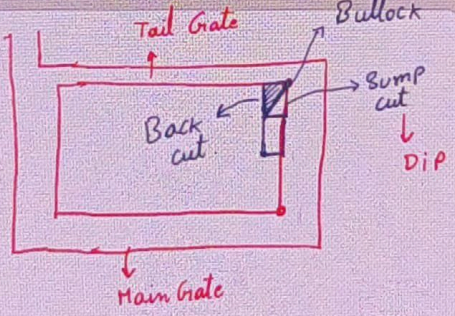
Stable → In longwall advancing
↳ extended portion of gate roads beyond face
To be provided where
↳ haulage rope / belt conveyor used in gate road
also required by cutting / cutting loading m/c.
↳ for proper utilisation
→ stable are 8-10m ahead of face.
→ helps to explore face



→ Buttock depends on the orientation of coal seam



Length of Longwall face
→ It depends on.
① Output desirable → for continuous flow of coal at least have 3 or more longwall face.
↳ It depends on
① working section of seam.
② length of face.
③ it advance per day

→ It depends on.

① Output desirable → for continuous flow of coal at least have 3 or more long wall face.

↓ It depends on
① working section of seam.
② length of face
③ its advance per day

② Haulage & Control Unit

travel of shearer → effected by mechanical/hydraulic system

hydraulic system → operated by hydraulic controls
↳ Provides variable speed of travel. (0 - 0.12 m/s)
↓ governed by load on electric motor.

Mechanical system → haulage system
↳ Controlled by multi fixed haulage speeds.

Radio Control / Remote Control → Transmitter carried by shearer operator
↳ Reciever within the m/c
↓ operates hydraulic valve

↓ It can be operated from a distance of upto 10m from m/c.

③ Motor Unit → Provides power from 2.25 kW to 1000 kW
↓ by 1 or 2 electric motors
↓ max.m Voltage - 4.2 kV

face advance by shearer → 2.4 m to 3m per shift
↓ Prod.n 1000 te/day
↓ It depends on
① Type of m/c
② Seam thickness

Pathakhera Colliery (WCL)

→ DERD longwall face

→ Seam thickness → 1.3m - 1.7m.

→ Depth of seam → 100m

→ face length - 110m

→ Method → Longwall retreating with caving

Main items

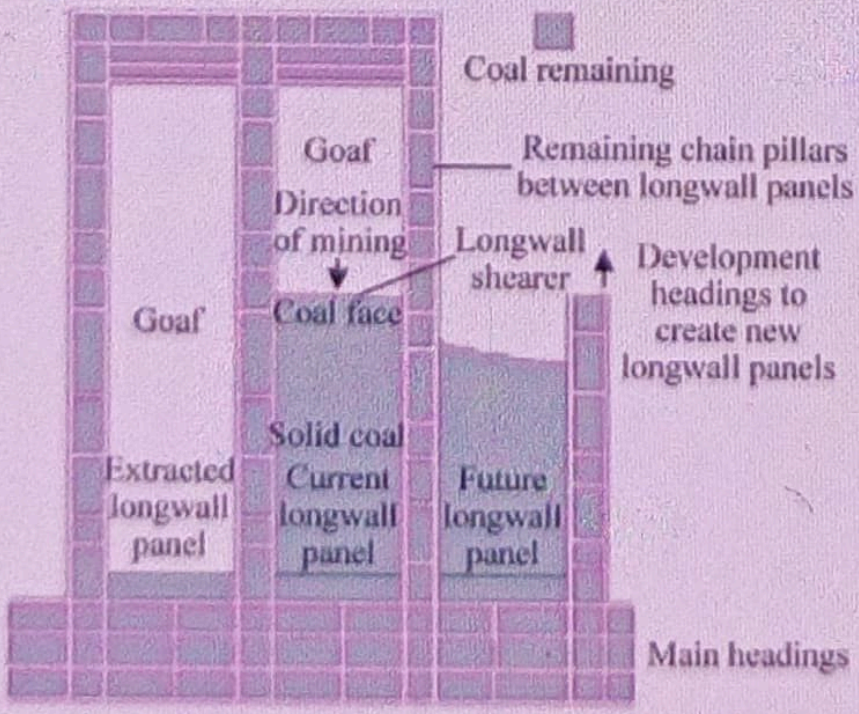
① Support system 6 leg 240 te

② DERD 200 KW power

③ AFC → 2 × 90 KW.

④ Stage loader → 90 KW

Grate Belt Conveyo
1000mm width
90 KW motor



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Longwall Equipments

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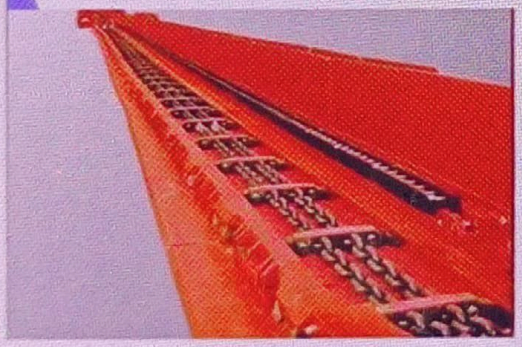
① AFC → Armoured face Conveyor

- It is a face conveyor on which shearer is mounted
- 2 x 115 KW 2 motors on one end
- Capacity 800 to 1000 tonne/hour

Armored Face Conveyor



② STL → Stage Loader

- Short length Conveyor
- Capacity same as Gate Belt Conveyor
- helps in movement of face
  ↓
  Gate belt Conveyor को daily adjust नहीं करना पड़ता है।
- 100 to 150m of face movement is possible
  ↓
  उसके बाद Gate belt Conveyor को adjust करना पड़ता है।

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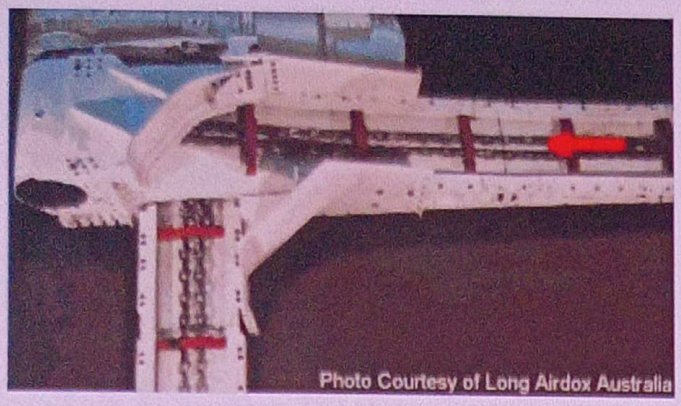

③ Chute & Feed Arrangement.

Prevents spillage of Coal while transfering to gate belt.

④ Feeder breaker

To Crush oversize Coal.

⑤ Pantechnion → A rail mounted trolley over which the switches of different equipments, transformer, power pack etc. are kept.

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⑥ Power Pack → Assembly of pump, a storage tank and different valve for operational control.

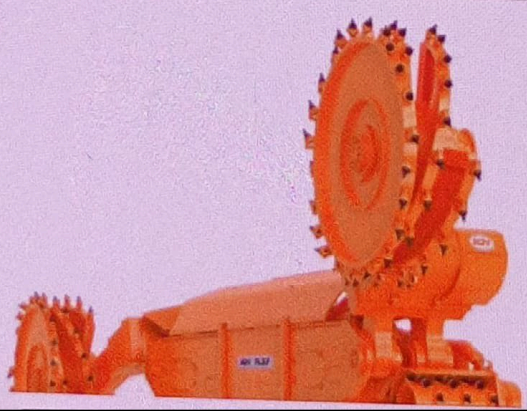
fluid → 95% distilled water
↓
5% mineral oil

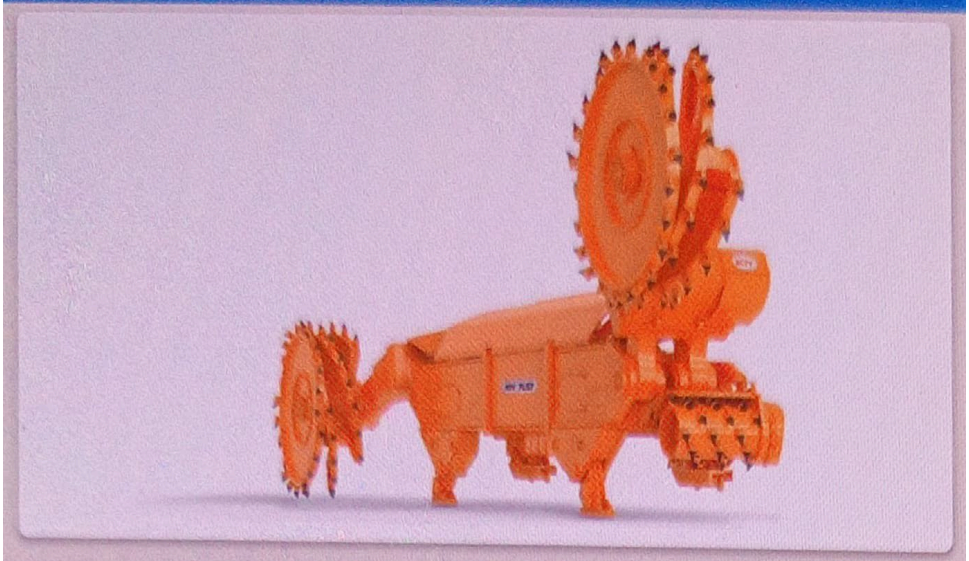
⑦ Grate Belt Conveyor

- Capacity 900 TPH (Tonnes per hour)
- Drive Generally 150KW to 200KW, it depends on length of conveyor.
- Standard width 1.2m

⑧ Shearer (DERD) Double ended Ranging Drum

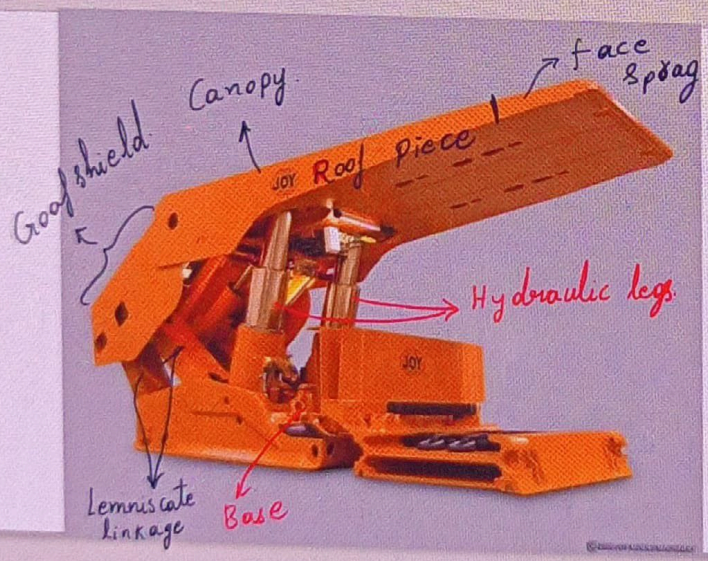
→ used for coal winning
→ It has 2 cutting drums
→ Drums can be ranged upto a limit
↓ raise ↘ Lower
→ Low dia drum is generally fitted on rise side
→ Width of drum 0.6m with cutting bits
→ Power 400 to 450 kW
→ RPM → 25 to 40 RPM
→ cutting speed 2.5m per minute

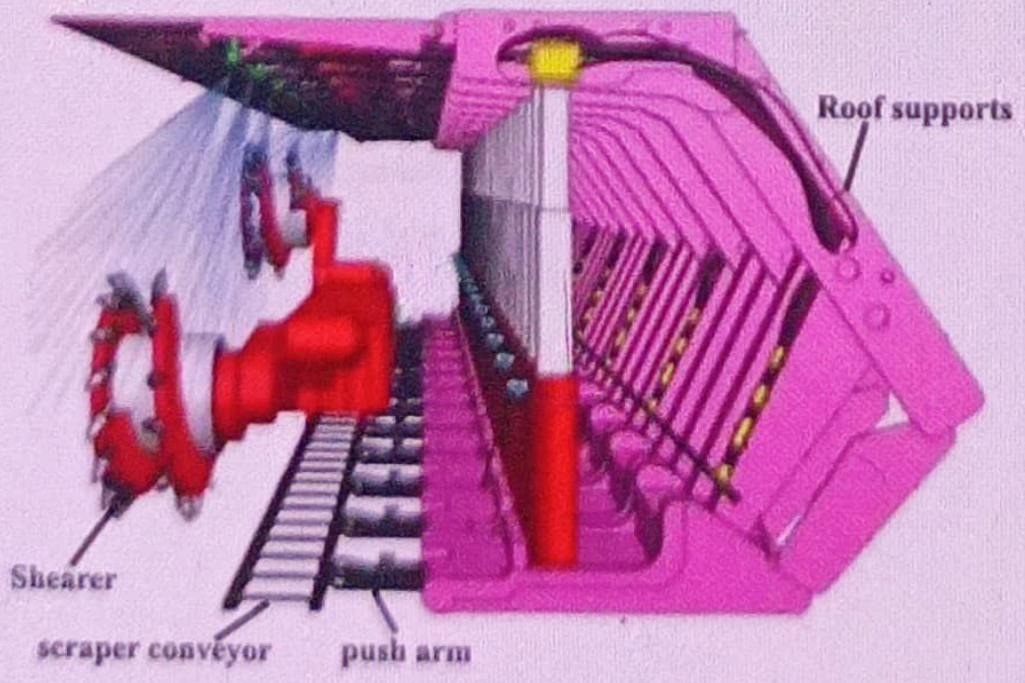




(9) Shield support

- Combination of chock & shield
- It has 2, 4, 6 Vertical hydraulic props
- Roof piece on top.
- Erected over whole length of face
- Size 1.5m X 4.5m,
- Capacity 250 to 450 T
- Triple Telescopic leg → to support upto 5m.
- Lemniscate Linkage → combination of levers. helps in keeping the roof ll to floor.




Roof supports
Shearer
scraper conveyor
push arm

Face operation and production

By – Devendra Singh Tomar

MINING GYAN

Longwall mining

→ In this method galleries are driven

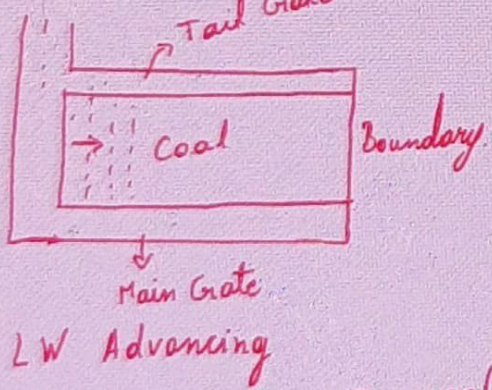
→ Galleries are separated from each other 60 – 200m or 300m apart

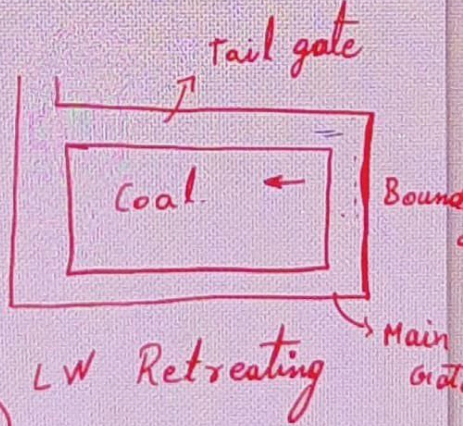
→ Joined to form longwall face

→ Longwall advancing → Extraction of LW face advancing towards the mine boundary or panel boundary from the point of entry.

→ May be done with caving or stowing.

→ Packwall to be constructed to maintain gate roads by strip packing.





Drivage (Tail/Main Gate)
↳ CM, Roadheader, Dint header

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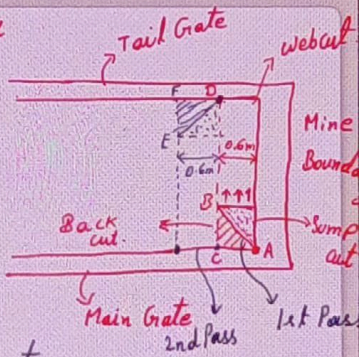
Longwall Advancing	Longwall Retreating
① Quick Return of capital	- Delayed return of capital
② Gate roads are in goaf side and difficult to maintain	- Gate roads are in solid coal and easy to maintain
③ There will be always leakage through the Goaf which reduces VEQ and increases chances of fire.	- There is no leakage to the goaf, hence VEQ is more & chances of fire is less.
④ Difficult Technology	- Easier technology.
⑤ Geological disturbances are not known in advance	- Geological disturbances are known in advance.

Causes of LW failure in India

→ Inadequate exploration 16 holes/sq.km. in other countries 30 holes/sq.Km.
→ Our coal seams are hard & thick
→ Hard roof causing delay in caving.
→ Equipments & spares are to be imported
→ High capital cost.
→ No skill & culture
→ More geological disturbance
→ Poor maintenance.

Operation of Shearer



→ Point A → Buttock.
→ A to B तक नौ cut मारेंगे Tringle shape में उसे sump cut कहते हैं
→ B to C तक Backward cut पतलन की Back cut मारते हैं।
→ B से D तक 0.6m का web cut मारते हैं।
→ Sump cut + Back cut + web cut → Pass cut

→ Sump cut → nearly 30m → Drum enters into coal face
→ Back cut → Shearer moves Back ward.
→ 10 passes per day. ⇒ 1 pass ⇒ 0.6m advance
10 passes ⇒ 6m advance.

→ AFC → Snack } to match with face.
→ Powered support → advance }
... length of powered support.

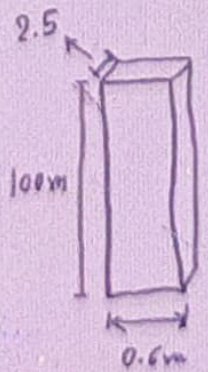
→ AFC → Snack
→ Powered support → advance } to match with face.

→ Span depends on length of powered support.

Production Estimation from longwall face.

Seam thickness ⇒ 2.5m
No. of passes per day ⇒ 10
Length of face ⇒ 100m
Width of web ⇒ 0.6m
Sp. gravity of Coal ⇒ 1.3 → $1m^3$ of 1.3 tonne Coal.
Daily production ⇒ ?
Operational factor ⇒ 0.7

Daily Prod.^{n} = 100 × 2.5 × 0.6 × 1.3 × 0.7 × 1
= 1365 Tonne.



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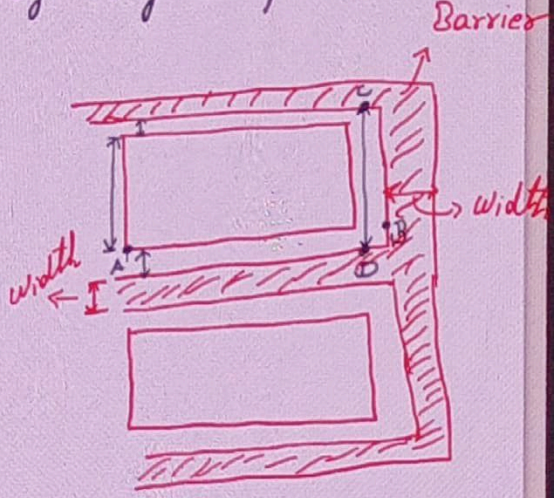
Cyclic LW/Conventional	Non - Cyclic LW
① With undercut / Solid blasting	① No drilling & blasting, use of shearer or coal plough
② Support by props/cogs/Crossbars etc.	② Support by powered support
③ Loading on conveyor by shovelling	③ Loading by shearer/plough automation on AFC
④ Less production 200-250 TPD	④ More Production 1000-1400 TPD
⑤ Semi Mechanised	⑤ Fully mechanised.

Barrier Width

→ Geo Technical parameters of roof & floor
→ Depth
→ Panel length & Width
→ Coal strength
→ width of barrier = $\left(\frac{\text{Depth}}{10} + 15\text{m}\right)$



example ⇒ Depth ⇒ 200m

$$\text{width} \Rightarrow \frac{200}{10} + 15$$
$$\Rightarrow 20 + 15$$
$$\Rightarrow 35\text{m}$$

Horizon Mining

→ Method of approach to reach the coal seam.
→ उसके बाद basic method of mining
↳ LW / B&P
→ इस method में coal seams level roads की help से open किया जाता है
Roads को shaft से coal seam तक rock में drive किया जाता है।

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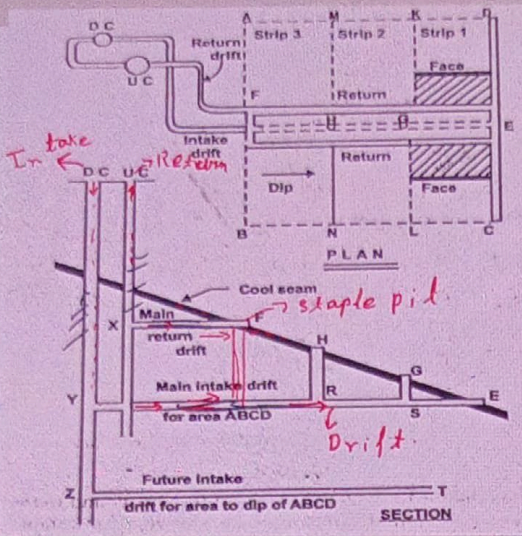


→ Lower level → Coal transport haulage
↘ Intake airway

→ Upper level → Return airway
↘ Material supply gate

→ Seams/Levels के बीच में Connection staple pit बना कर करते हैं।

→ Applicability → steeply inclined seams.

General Considerations before adopting horizon mining

→ Large reserve required
↓
To justify high capital expenditure → Shaft sinking
↘ Drifting

→ Reserve estimation के लिए exploration adequate होना चाहिए।

→ Availability of → more no. of seam
↘ Thick seams.

→ Strong strata → लंबे समय तक roadways safe रखने के लिए

Advantages of Horizon Mining

→ Roads are level → mechanised transport system
↘ Loco motives can be used

→ Efficient Ventilation → Less leakage

→ Less maintenance cost of roads
↓
... roadways are in solid stone

Advantages of Horizon Mining

→ Roads are level → mechanised transport system
→ Locomotives can be used

→ Efficient Ventilation → Less leakage

→ Less maintenance cost of roads
↓
because roadways are in solid stone

→ Easy to work in several seams simultaneously.

→ Bad roof होने पर seams में effectively work कर सकते
because roadways stone में होते हैं।
→ best for steep seam

Disadvantages of horizon mining

→ high capital expenditure → for development

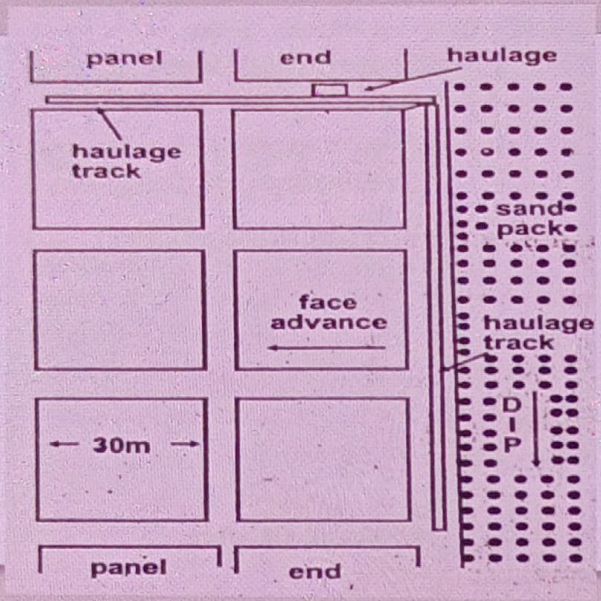
→ Prod.ⁿ target achieve करने में बहुत time लगता है

→ Large reserve required

MINING GYAN

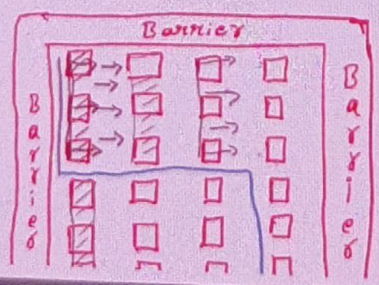
Barry face

→ A modified method of longwall retreating with sand stowing
↳ done over already developed mine by B & P method
→ Pillar size 35 - 45m Centre to centre
→ 3 pillars along dip rise in a straight line are used to provide longwall face.
→ Extracting pillars and stowed goaf के बीच में haulage track होता है for tubs.
→ haulage track → No timber sleepers are used
↳ 2m long rails welded to channel.



→ Main & tail haulage system is used.
→ OMS by manual loaders was 4 - 5 tubs of 1.1 m^3 Capacity

Cyclic LW
Blasting & manual loading
↓ ...d stowing

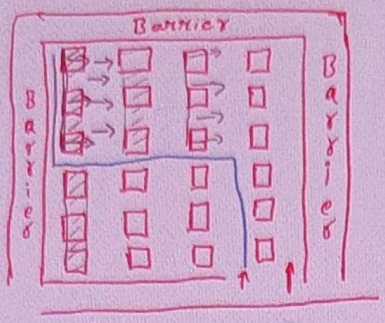


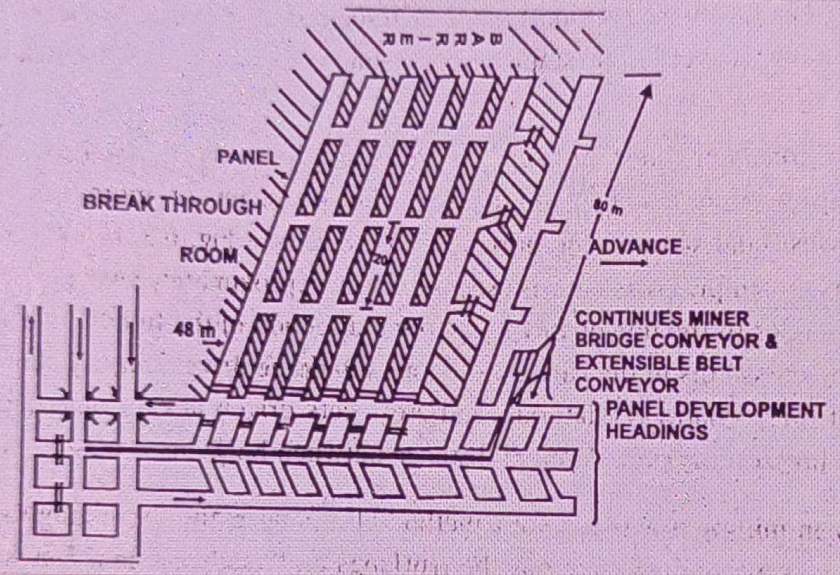
Cyclic LW

Blasting & manual loading

↳ Sand stowing.

Dip ↕ Rise





Room & Pillar Mining

→ This method consists of splitting the mining area into districts ⟶ 3 – 10 headings/main entries.

↓ driven at intervals of 800 to 1500m.

↳ width → 3.8 m to 5.4m.

Centre to centre → 15m to 25m.

2/3 headings driven at right angle.

↓ room entries ↳ width → 4 to 5m

↳ panel butt ↳ centre to centre. 12m to 27m.

Disadvantages of Room & Pillar mining.

① No. of machines are larger than required

↓ To be moved frequently ⟶ maintenance & operation Crew.

② Amount of capital investment required per tonne of annual output is larger.

③ Percentage of recovery is less than longwall

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annual output is larger

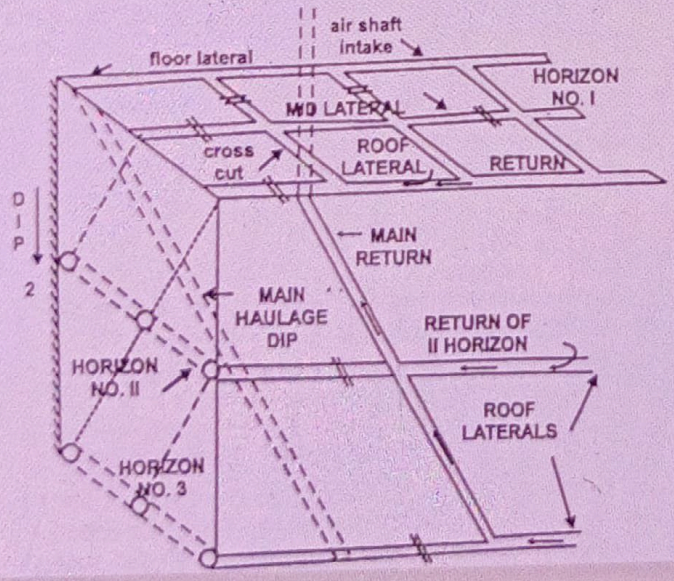
(3) Percentage of recovery is less than longwall

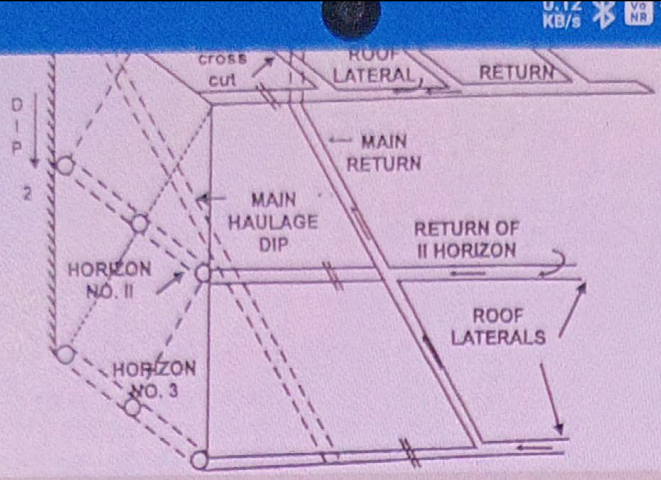
Application of this method

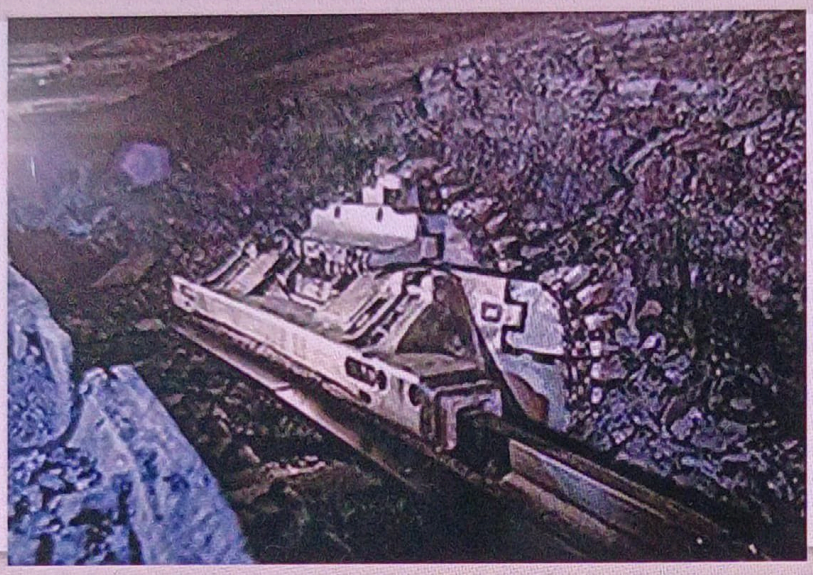
→ Flat seams
→ Thickness ⇒ 1.2m to 4m.
→ Seams must be free from geological disturbances
→ Depth must be less than 300m
→ Large reserve required.

Level Mining or Semi-Horizon Mining

→ Development → B & P method
↓
Seams → Thick, steeply inclined
↳ main dip ⊥ उत्तानता all roads in the seam are level.
→ Parting b/w horizons shall not be less than 3m
→ main advantage → gallery in a horizon is levelled
↳ efficiency of machineries & workers increases
↳ high capacity transport from face.




cross cut
ROOF LATERAL
RETURN
DIP
MAIN RETURN
MAIN HAULAGE DIP
RETURN OF II HORIZON
HORIZON NO. II
ROOF LATERALS
HORIZON NO. 3

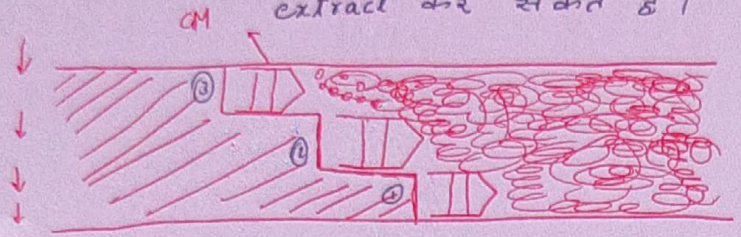


MINING GYAN

Thick Seam Working

→ Seams more than 4.5 m thick → are called thick seams in India.

→ Thick seam → यह एक lower limit होता है seam के thickness की जिसे एक lift में extract कर सकते हैं।



Problems of Mining thick Coal seams.

1. Extraction height increases, more strata load require heavier support.
2. Strata control is difficult → Overriding of pillars
   ↓
   Premature collapse of pillars. (B & P workings)
3. Inspection of roof is difficult → Roof fall accidents
4. Low % of extraction → Risk of spontaneous heating
5. Bad Ventilation → due to high working.
6. Subsidence control is difficult → Methane layering near roof.

Methods of Mining thick Coal Seams

- B & P → Single lift (Cable bolting) (6 - 8 m thick seams)
- Hydraulic mining
- Multilift → Multilift with full stowing
- Multilift with stowing excepting the uppermost slice
- Blasting gallery method
- L W
  - Single lift LW (upto 5.5m thickness)
  - Slice Mining with caving
  - Slice mining with stowing
    - Inclined Slicing → Ascending order
    - Horizontal slicing → Mixed (ascending & descending order)
    - Vertical Slicing → Descending order

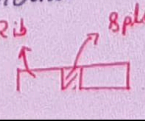
Extraction of thick Seam with Cable bolting

→ Cable bolting → Depillaring in thick seams.

↓ ↳ Suitable for seams of thickness 6m to 8m.

It is an upgraded version of Rib & Slice method

→ उससे seams की thickness 8 m से



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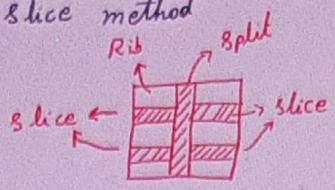
It is an upgraded version of Rib & slice method



→ अगर seams की thickness 8 m से अधिक है तो ज्यादा thickness के ribs छोड़ना पड़ेगा

→ Cable bolting, drilling, charging & blasting will be difficult ↓ requires sophisticated equipment.

→ Can be worked by B & P method

Cable bolt

→ length upto 20 - 35m

→ wound on spool can be cut to any length and is easy to operate.

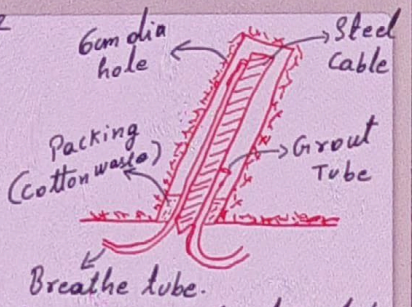
→ used with other bolting system as a reinforcement (Backup)

→ It has steel cables grouted in drill holes in rock

→ steel cables are made of 7 steel wires

→ Grout → Mixture for filling holes.
↓
Water & Cement → Ratio → 0.35:1 to 0.5:1

→ Cable bolts can be installed at any angle.



→ Cable and breather tube hole में पहले insert करते हैं।

→ Grout tube को 1m की depth तक insert करते हैं

→ hole के bottom में 30 cm तक packing करते हैं।

→ Breather tube → allows air to escape, displaced by Grout.

→ Grout से hole भर जाने पर tube के ends को fold कर देते हैं।

→ Tubes को recover नहीं करते हैं।

→ Load carrying capacity → It depends on failure strength
↓
① Cable & grout
② Interfaces b/w
↓ ↓
Cable grout rock & grout

→ Cable - grout interface usually breaks first.
↓
This is the main weakness of system.

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Gunite

→ Gunite → It is pneumatically applied portland sand cement mortar
- → Used to support mine opening & prevent weathering
- → Sometimes used wire netting embedded in Concrete.

→ Guniting → It is a process, where dry mixture of sand and cement along with water is applied to the surface.
- Uniform grain size

→ 1 part of sand & 3 to 4 parts of cement

→ By cement gun

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is applied to the surface.

Uniform grain size

→ 1 part of sand & 3 to 4 parts of cement

→ By cement gun

rubber hose pipe & spray nozzle by pneumatic pressure (2.25 to 3.5 kg/cm²)

→ Nozzle में high pressure water jet की help से mixture में hydration provide करते हैं।

→ Pressure of water → 3.75 to 4.5 Kg/cm²

→ Quantity of water → Variable → depends की guniting कहाँ पर कर रहे हैं

horizontal / Vertical surface

→ Cement - Sand proportion → depends on required thickness of gunite

15mm to 75mm

→ Nozzle held at a distance of 1m to 1.25m

→ Thicker layer में लिए coating की जाती है।

after hardening of surface

Shotcrete

→ Concrete projected on rock surface pneumatically
→ Mixture → Concrete, aggregate, accelerator
(gravel, sand, crushed rock)
→ Used → in tunnels & mines for primary support
↳ as a sealant in tunnels
① To prevent weakening of rock
② To reduce water inflow
③ To cover rock bolts, mats and wire mesh

Slice Mining

→ It means development & extraction of thick coal seams in multislices.
→ Thickness of slice → easy extraction in one pass
→ Successfull in LW method
→ Coal seam is divided into suitable thickness of slices.

Thick Seam Longwall (caving)

→ Present day technology permits a seam thickness upto 5.5m to be extracted by PSLW equipment in one lift.
→ Seam thicker than 5.5m are extracted by following caving LW method:-
① Multislice system → top to downwards (descending order)
② Integrated caving system i.e along the floor 2.5m की height का slice work करते हैं and साथ ही upper caved coal का goaf side से extract करते हैं।
③ Combination of above two methods by.
ⓐ Working slice (2 to 2.5m high) along the roof allowing the strata to cave.
ⓑ Working at bottom slice and winning middle coal from goaf side

Multi slice Longwall

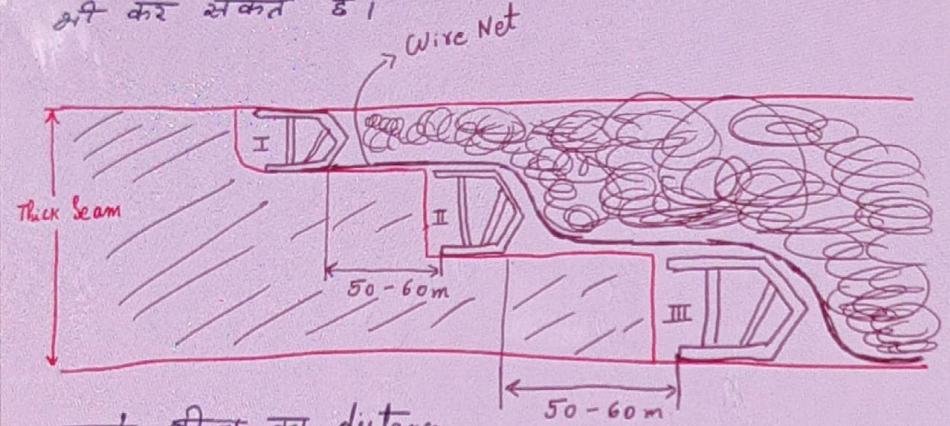
→ LW slices are taken one by one from roof to floor

→ Top slice is worked like PSLW face, wire net को Powered support के ऊपर बिछा देते हैं।

→ Wire net seam के roof के नीचे होता है या फिर first slice के coal floor पर होता है
  → to separate goaf of caved roof from next slice

→ Wire net एक artificial roof की तरह work करता है।

→ Slices में work एक-एक करके या फिर एक साथ भी कर सकते हैं।



→ इनके बीच का distance 50-60m होता है।

Integrated caving System

→ floor के पास 2.5m high slice में work करते हैं and साथ ही upper caved coal को goaf side से extract करते हैं।

→ entire seam is worked in one operation

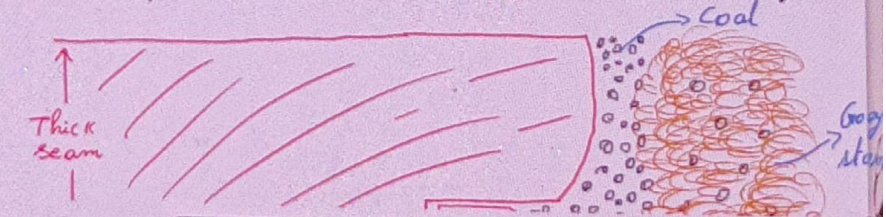
→ The face has two Armoured face chain (AFC) conveyor
  → one on front side
  → other on goaf side

→ The rate of advance is dependent on rate of coal recovery from goaf side

→ Only 60-65% of goaf coal can be recovered.

→ Coal recovery को goaf side में बंद कर देते हैं जब ज्यादा rocks, coal के साथ आने लगते हैं।

Risk → high risk of sp. heating as a result method is adopted where incubation period is high.



is adopted where incubation period is high.

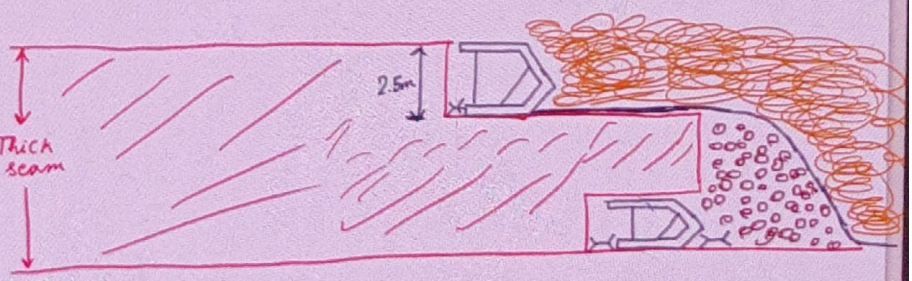
Combined Method

→ When roof of thick coal seam is strong & massive

→ सतलन कुछ दूर तक hang हो सकता है before coming down and also coal के ऊपर भी कोई Pressure नही डालेगा।

→ Along the roof पहला slice cut करते है like Conventional PSLW face and साथ ही floor पर Wire net बिछाते है to make false roof

→ फिर integrated caving method से floor level face पूरा coal recover कर सकता है।



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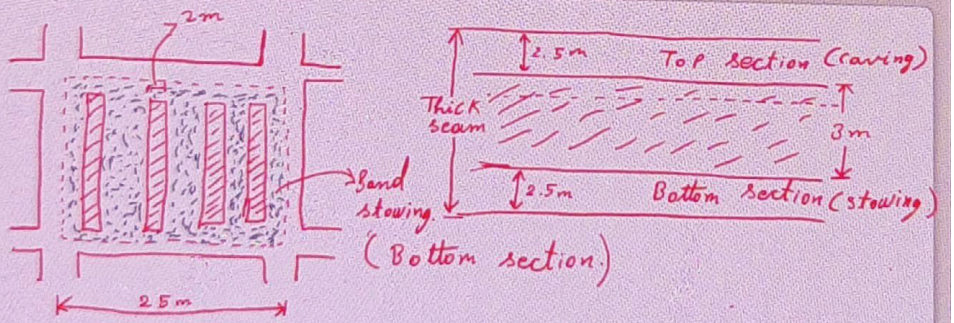
MINING GYAN

Thick Seam Mining by B & P method

→ Bottom section stowing & top section caving
→ Coal seams → Less sp. heating } very successful
↘ 8m thick
→ Seams को 2 sections में develop करते हैं।
→ height of each section is 2.5m and 3m parting in b/w
→ width of galleries → 4.2m
→ Pillars and galleries दोनों sections में vertically one above the other होते हैं।

→ bottom section में pillars को split किया जाता है (width 4.2m & height 2.5m)
→ 2m की rib छोड़ते हुए किया जाता है।
→ dip-rise में split करते हैं।
→ split को dip to rise stow किया जाता है।
→ bottom section में depillaring with stowing complete होने पर top section में depillaring with caving start किया जाता है।
→ Top section में floor coal को extract करके gallery height 3.5m तक किया जाता है।



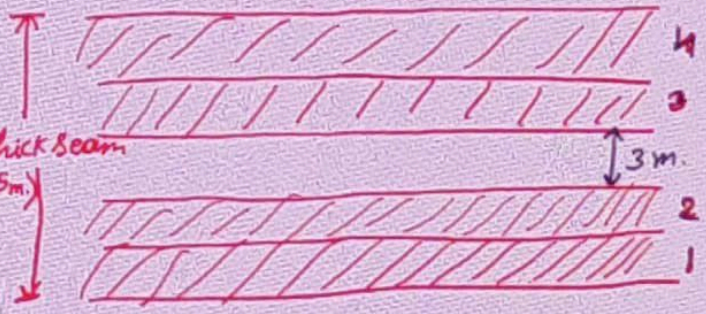
Multi lift extraction by total stowing in B & P System

→ Ascending method of slicing is followed from bottom section
→ Thick seams upto 20-25m can

Multi lift extraction by total stowing in B & P System

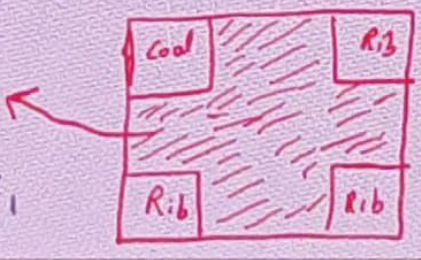
→ Ascending method of slicing is followed from bottom section

→ Thick seams upto 20 - 25m can be extracted by this method by making several slice.

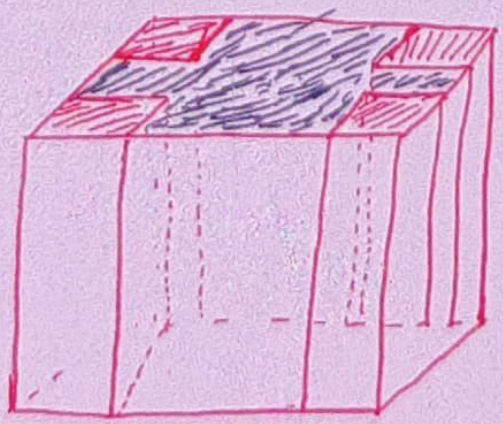


→ starting bottom section को develop करते हैं
(gallery width 4.2m, height 2.5m)

→ दोनों sections में fully stowing करके extraction करते हैं।



→ इसके बाद 3-4m की parting छोड़कर 3rd & 4th section को भी same तरीके से ही extract करते हैं।



MINING GYAN

Precautions according to DGMS

(1) Before starting extraction accurate survey shall be conducted.

(2) Depillaring operation तब तक नहीं करेंगे जब तक panel को effectively isolate ना कर दिया जाए
↓
To prevent danger to other panels from gases / Innundation.

(3) Depillaring करते समय pillars को 4 parts में split करते हैं।
→ level split galleries (4.2m width)

(4) → Resultant stook not less than 5m X 5m from corner to corner

(5) splitting of pillars shall start from dip most area of panel

(6) Not more than 2 pillars shall be under splitting at any time

(7) while developing pillars over sand, the gap formed due to shrinkage of sand shall be filled up as far as possible while taking the upper lift.

(8) Regular gas sampling shall be done to detect % of gas in return air.

(9) During extraction, proper subsidence record on surface shall be maintained.

Blasting Gallery method for Thick seam Mining

→ In B&P method for seams thicker than 6m.

→ This method consist of drilling & blasting

→ Gallery is driven ↙ fan like ring of boreholes in Coal

→ This method consist of drilling & blasting
  - fan like ring of boreholes in coal
  - Varying length & Inclinat & direction.

→ Gallery is driven along the floor of the seam.

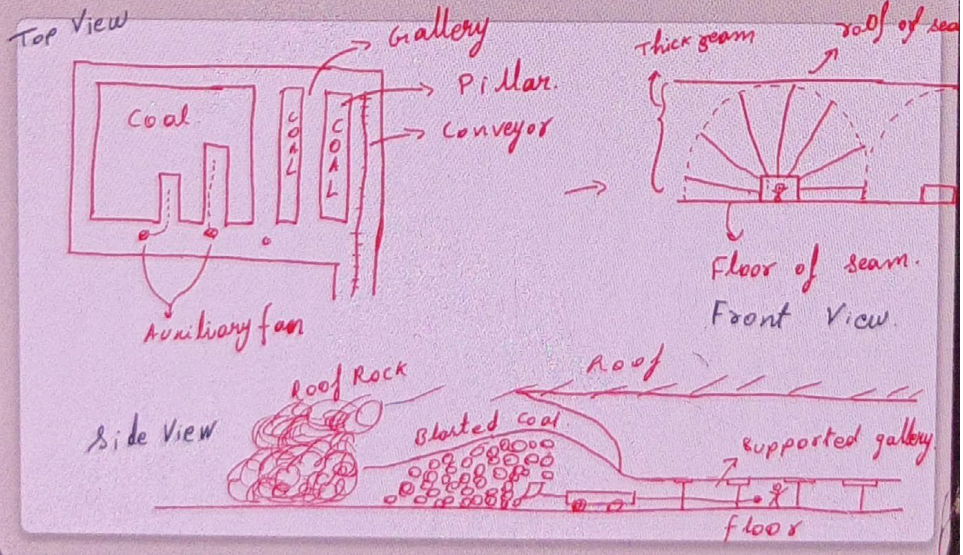
→ Fan type holes are blasted and coal is loaded by remote controlled loader (LHD/SDL)

→ Remote Controlled LHD → gradient → 1 in 7 or flatter
  - bucket capacity 3.5 m^3
  - floor => hard & not wet.

→ Remote controlled SDL → gradient → steeper than 1 in
  - floor → wet.
  - 4.1 m^3

→ Support → depends on width of gallery

→ gallery width → 4.2 m.

→ Support → timber props → to get additional indication of roof weight

→ Production → 1000T – 3000T/day.